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this report examines the nature of and trends in water quality; describes the status of public sewerage services and the costs of municipal facilities to meet the 1977 standards; describes the costs of controlling industrial nonthermal pollution; reports on the capacity of U.S. agriculture to meet food and fiber demand to the year 2000 under environmental restrictions on soil loss and use of nitrogen fertilizers; introduces benefit analysis; and reviews potential problems in implementing the 1972 Amendments.

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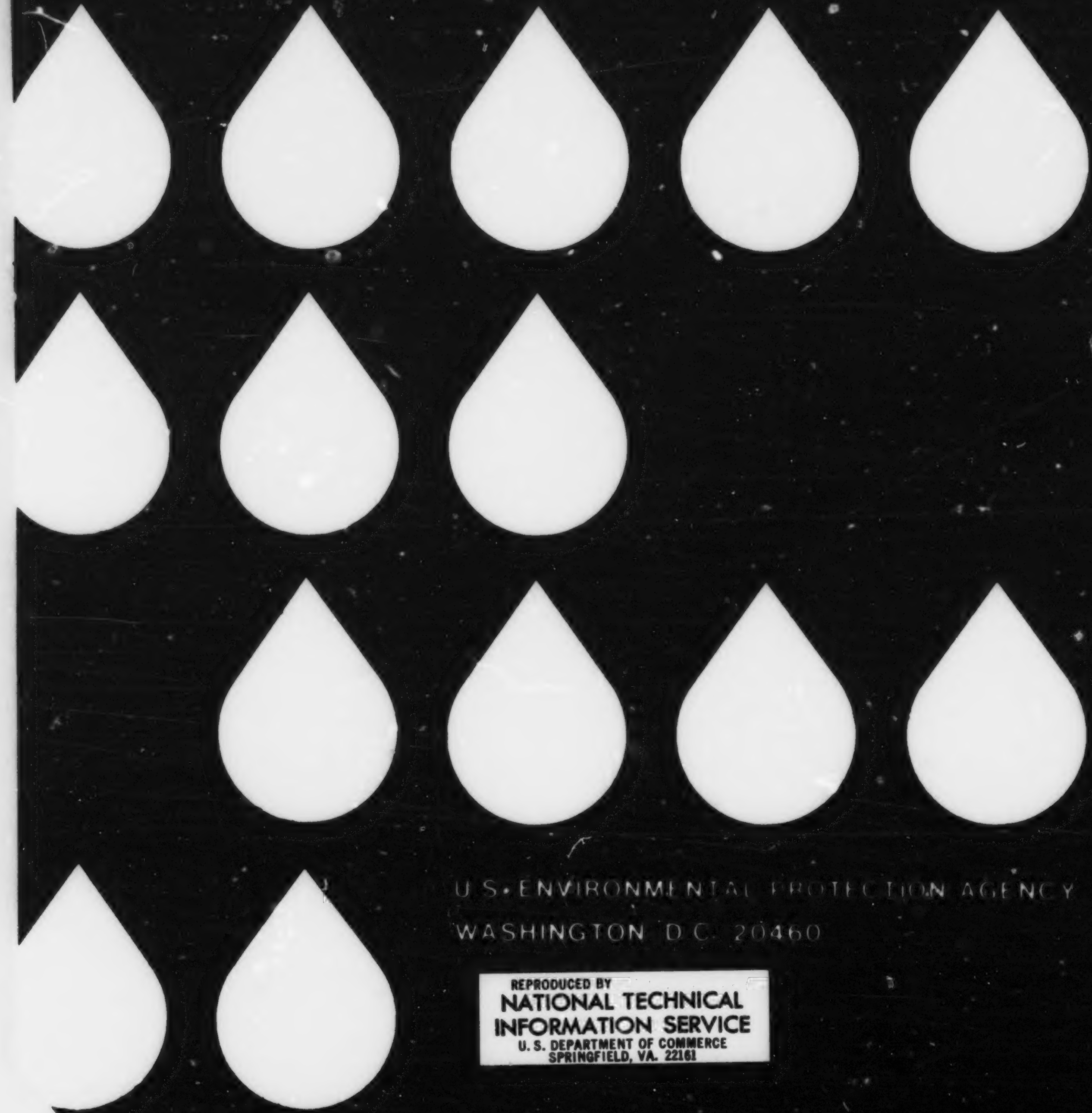

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THE ECONOMICS
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U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460
DECEMBER 1973

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

December 28, 1973

THE ADMINISTRATOR

Dear Mr. President:
Dear Mr. Speaker:

I am pleased to transmit to the Congress, as required by Section 516(b) of the Federal Water Pollution Control Act, the sixth of a series of reports on the Economics of Clean Water.

The scope of the report is broader than previous reports. For the first time, economic factors—essential to a broad assessment of control programs and policies—are examined. Particular attention is afforded those factors that may constrain implementation of control programs. Also examined for the first time are two major sources of nonpoint pollution—agricultural soil loss and nitrogen fertilizer. The following material briefly describes the highlights of the report.

The quality of the Nation's waters can be discussed in only approximate and qualitative terms, since no set of truly representative water quality monitoring stations exists. An EPA study, however, provides preliminary information on the status of and trends in water quality for 22 major river basins. The study indicates that bacteria and oxygen demand, the pollutants receiving the most widespread attention, showed general improvements in the last five years. Phosphorus and nitrates, the primary pollutants contributing to eutrophication, increased over the last five years in many of the basins.

A survey made by EPA in mid-1973 estimates that the costs of municipal treatment and collection facilities eligible for Federal funding will be \$60 billion (1973 dollars). This is comparable to the total dollar investment made in the sewerage systems of the Nation since 1855. Of the estimated \$60 billion, \$36 billion is needed for waste treatment plants and interceptor sewers, and \$24 billion for correction of infiltration/inflow problems, new collectors, and combined sewer overflows.

Industry will be required to invest about \$12 billion in treatment facilities within the next few years to meet 1977 standards (except thermal) set by the Federal Water Pollution Control Act Amendments of 1972. The cost estimates suggest that industry will have to invest an average of about \$3.5 billion annually in order to meet the 1977 nonthermal standards. In 1972 industry was investing at an annual rate of \$1 billion. Thermal costs, which are estimated for only utility steam-electric generating plants, are expected to range from \$2.3 to \$9.5 billion, depending primarily on the number of plants exempted from thermal standards.

The productive capacity of the agricultural sector is not expected to be impaired while taking measures to reduce pollution from erosion and use of nitrogen fertilizers. It is expected that environmental protection measures might be designed to control agricultural pollution with no reduction in total farm income. It is further expected that such measures could be designed to control agricultural pollutants for a cost on the order of magnitude of that incurred during the peak of the Nation's cropland restriction program.

Estimating benefits of the water pollution control program is a difficult task. Admittedly, if a change in water use is specified, there are several promising procedures for assigning monetary values to the uses. But there are great difficulties in tracing the effects of an abatement program to changes in water quality parameters, and in relating such parameter modification to man's use of the water or the adjacent shoreline.

The economic impacts and other constraining factors examined, other things being equal, in EPA's view should not significantly retard the accelerated program launched by the 1972 Amendments to control pollution from municipal and industrial sources. In particular:

- Local governments, with few exceptions, will have adequate capability to finance their share of building sewerage systems. The combination of the State grant/loan programs, the U.S. Environmental Financing Authority and the Farmers Home Administration loan program should be able to assist an individual municipality having a financial problem.
- An overview of 23 industries discharging directly into the Nation's waters indicates that in most cases they will be able to recover the costs of wastewater treatment through increases in prices. However, individual plants in certain industries will experience difficulties in meeting the requirements. The profitability of smaller and/or older plants may be so reduced that some of them may decide to close prior to 1977.
- The results of econometric models indicate that the construction industry should be able to build the required facilities with real price increases of less than 1 percent attributable solely to EPA-stimulated demand, assuming resource transferability within the construction industry. The skilled labor needed should be available, but there will be some impact on wages. In some localities, the construction industry may lack adequate short-term capacity, especially in light of changes in the Nation's economy that may result from the recent devaluations and the energy crisis.
- The potential profitability of the pollution abatement equipment industry is attractive enough to encourage the growth and development of long-term supply. Production capacity as estimated in 1972 is not viewed as a constraint. However, raw material and skilled labor inputs may be constraints in some cases.

Other things being equal, the economic factors examined are not expected to seriously constrain efforts to meet effluent standards. (However, the other things assumed equal may not be equal. Unforeseen events such as the energy crisis or the recent devaluation of the dollar may lead to basic changes in the economic system, resulting in outcomes different than those predicted.) Other factors, such as budget constraints both in the public and private sectors and legal and administrative steps that must be taken in controlling wastewater discharge, could result in delays.

As long as there are significant non-point sources of pollutants, control of industrial and municipal sources does not mean that all areas of the Nation will have clean water at the same time. A fundamental question remains: At what point do the additional costs of controlling all sources of pollution exceed the additional benefits of improved water quality? Clearly the current societal concern for environmental quality indicates that the public believes there are significant benefits yet to be attained.

Sincerely,

Russell E. Train

Russell E. Train

Honorable Gerald R. Ford
President of the Senate
Washington, D. C. 20510

Honorable Carl B. Albert
Speaker of the House of Representatives
Washington, D. C. 20515

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I. Introduction

SCOPE

This report is the sixth in the series of Clean Water Reports to Congress and the first prepared in accordance with Section 516(b) of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500). The scope of the 1973 report is broader than previous reports because the U.S. Environmental Protection Agency (EPA) recognizes that consideration of the costs of controlling pollution from municipal and industrial sources is not sufficient information upon which to evaluate a national program. Information about the nature of the water quality problem, the costs of controlling all significant sources of pollution, potential benefits, and economic and administrative factors that influence implementation must also be considered in order to place the costs of controlling point sources in perspective. While this year's report addresses all these issues, it primarily focuses on some of the economic factors that will influence implementation of the 1972 Amendments.

The first chapter, in addition to introducing the report, summarizes its content and conclusions.

The second chapter of the report examines the nature of and trends in water quality. While the main body of the report focuses on the costs of controlling only certain pollutants and pollution sources, it is important to recognize that achievement of water quality will require more than control of those pollutants and pollution sources.

The third chapter describes the status of public sewerage services and the costs of municipal facilities to meet the 1977 standards as reported in a nationwide survey of municipal sewer and treatment plant needs.

The fourth chapter describes the costs of controlling industrial nonthermal pollution for meeting the 1977 effluent standards. In addition, it reports on the costs of controlling industrial thermal pollution to meet both the 1977 and 1983 standards.

The fifth chapter reports on the capacity of U.S. agriculture to meet food and fiber demand to the year 2000 under environmental restrictions on soil loss and use of nitrogen fertilizers. The discussion of agricultural pollution control is the first in this series of reports.

The sixth chapter is an introduction to benefit analysis. The 1972 Amendments state that formal cost/benefit analysis should be conducted and used in the decision process, although the law does not allow such analysis to override legislatively mandated effluent limitations.

The seventh chapter reviews potential problems in implementing the 1972 Amendments. A national determination that water pollution control is in the public interest does not eliminate economic and administrative problems. The economic problems of concern in this report are the financial burdens placed on municipalities and industries as they meet the 1977 standards and the capacity of the construction and equipment supply industries to put in place the required capital without adversely affecting the levels, volume, and prices of construction and equipment, as well as wages and employment in those industries.

SUMMARY

Nature of and Trends in Water Pollution. Any practical description of the nature of water quality can only be concerned with a very limited part of all conceivable physical, chemical, and biological aspects of actual waterbodies. Typical water quality measurements are, in fact, oriented toward a small group of commonly observed pollution problems—harmful substances, physical modification, eutrophication, salinity, acidity and alkalinity, oxygen depletion, and health hazards and aesthetic degradation.

A stream of seemingly clean and pure water may be polluted due to the presence of hazardous substances in very low concentrations. A few of these are well known—heavy metals, pesticides, herbicides, and polychlorinated biphenyls (PCB's), for example.

Aquatic habitats are sensitive to fluctuations of many physical characteristics of water including temperature and transparency. Temperature fluctuations occurring naturally can be amplified by human activities through large discharges of industrial cooling water, such as from power plants or steel mills, from release of warm surface water held in reservoirs, or from destruction of shade trees along stream banks.

Relatively stagnant waters (such as lakes and slow-moving estuaries) rich in nutrients can grow such heavy crops of algal and other aquatic plants that the decay of dead cell matter may seriously deplete the water of oxygen. This prevents the survival of oxygen-sensitive food species and fish, and, in extreme cases, floating algal scum, thick bottom slimes, and odors result.

Major changes in the salt content of water can seriously disrupt aquatic communities and decrease the value of water for irrigation and water supply purposes. Acidity changes can be equally damaging by eliminating many desirable fish species. Alkalinity creates disruptions ranging from reduced agricultural production to the fouling of water pipes.

The dissolved oxygen level is widely considered to be the single most important indicator of pollution; actually, there is no reason to consider it more or less important than indicators such as toxicity, salinity, and algal population. Oxygen-consuming or oxygen-demanding substances come from many sources—forested and agricultural areas, industrial and municipal direct dischargers, storm sewers and sanitary sewer overflows.

An assessment of health hazards from polluted water involves considerable uncertainty because there are unresolved questions about the die-off rates of pathogens in natural waters as well as their infectiousness for swimmers or other recreational water users. The evidence for waterborne toxicity via fish and shellfish is stronger, at least in the case of relatively high concentrations of mercury and cadmium.

Waterbodies can be degraded aesthetically by increases in murkiness, color, algae, scums, floating solids and oils, and odors. Floating solids and oils generally originate in combined sewer overflows, storm sewer discharges, and unsewered runoff. Unpleasant odors can stem from many sources, including decaying organic matter and numerous industrial chemicals.

Status of 22 Major Rivers. During 1973, EPA studied 22 major rivers to define the kinds of pollution requiring control and to measure any improvement in water quality. The rivers, selected on the basis of length, flow, and proximity to large cities, were ranked in three groups from "cleanest" to "dirtiest." Rivers in the cleanest group are the Upper Missouri, Columbia, Snake, Willamette, Upper Mississippi, Yukon, Tennessee, Susquehanna, and Lower Colorado. Rivers in the dirtiest group are the Lower Red, Hudson, Lower Ohio, Lower Mississippi, Mississippi near Minneapolis, Upper Arkansas, and Middle Missouri.

Detailed analysis of 1963-73 data for the 22 rivers as a whole indicates that:

- The worst results relate to nutrients: Up to 54 percent of the reaches exceeded EPA phosphorus guidelines set to protect against eutrophication in flowing streams. Furthermore, in up to 84 percent of the reaches, phosphorus levels increased in 1968-73 over the previous 5 years. Nitrogen nutrients, while generally not exceeding reference levels, increased in up to 74 percent of the reaches measured.
- Other pollutants found in high concentrations are phenols (industrial compounds that can taint fish flesh) and suspended solids. These results are not as disturbing as the nutrient data, because in up to 80 percent of the reaches for which adequate data are available, concentrations of phenols and suspended solid levels fell in the last 5 years.
- The pollutants most widely controlled, bacteria and oxygen-demanding matter, generally declined in the last 5 years. Dissolved oxygen and oxygen-demand levels improved in up to 72 percent of reaches, bacteria in up to 75 percent.

In addition, the analysis examined nonpoint source pollution, which comes from runoff from areas such as farmlands, city streets, and mining areas, and from subsurface seepage from polluted areas. If nonpoint sources are present, runoff pollutants will generally be more prevalent in winter than in summer. The seasonal analysis indicated that most rivers have higher levels of nutrients (ammonia, nitrates, and phosphorus) and organic loads in winter, when runoff is heavy from rain and melting spring snow, than in summer. High flows in winter can also resuspend pollutants scoured from bottom sediments.

Municipal Costs. The sewerage systems of the U.S. have been growing for more than a century. The first sanitary sewer was begun in Chicago in 1855, but it was not until the 1870's that collecting sewers were complemented by treatment plants. Today, about 170 million Americans are served by sewers; more than 95 percent of them are also served by sewage treatment plants.

While the population served by sewers has more than doubled since 1937, the population discharging untreated wastes into our waterways is little more than one-seventh of what it was then. The number of persons whose wastes receive primary treatment [35 percent biological oxygen demand (BOD_5) removal] has almost tripled over the period. The number whose wastes receive secondary treatment (70 to 90 percent BOD_5 removal) has increased almost sevenfold; such treatment is now provided for the wastes of more than 63 percent of population served by sewerage systems. As a result, the amount of BOD_5 removed in 1971 exceeded the total collected by sanitary sewers in 1957.

However, the growth in sewerage facilities has brought disappointingly marginal results. While one portion of the public sewerage system—treatment facilities—increased by 130 percent the amount of BOD_5 diverted from our waterways, another portion—sanitary sewers—offset this improvement by collecting more BOD_5. Thus there has been a surprisingly small net reduction since 1957 in the oxygen demand introduced into our waterways by the public sanitary sewerage system.

Between 1855 and 1971, the Nation invested an estimated $58 billion (1972 dollars) in its public sewerage facilities. The bulk of this investment has occurred recently: almost 80 percent since 1929, 60 percent since World War II, and more than 30 percent since 1961. The net investment or replacement value in 1971 was estimated to be $32 billion. Replacing or modernizing this capital stock has absorbed 50 percent of all capital expenditures of sewerage agencies since 1961. Current replacement costs are close to $1 billion annually.

Needs Survey. The estimated total cost of constructing municipal treatment and collection facilities that are eligible for Federal funding under the 1972 Amendments is $60.1 billion (1973 dollars) according to the national survey conducted by the States and EPA in the summer of 1973. About $35.9 billion is for treatment plants and new interceptor sewers ($16.6 billion for secondary treatment required by the 1972 Amendments, $5.7 billion for treatment "more stringent" than secondary to attain water quality standards, and $13.6 billion for new interceptor sewers), $0.7 billion for rehabilitation of sewers to correct infiltration and inflow, $13.6 billion for new interceptor sewers, $10.8 billion for new collector sewers, and $12.7 billion for correction of overflows from combined sewers.

The $35.9 billion estimate for treatment plants and new interceptor sewers is considerably higher than the 1971 Needs Survey estimate of $18.1 billion for a variety of reasons, including:

- All municipal plants must now provide secondary treatment.
- Changing water quality standards require higher levels of secondary treatment (higher removal of organic waste) and special processes for removing phosphorus and nitrates.
- Construction costs rose by almost 20 percent between 1971 and 1973.
- The 1973 Survey's coverage of municipalities and their needs was far more comprehensive than those on which previous estimates of needs were based.
- More municipalities have completed engineering studies upon which to base their estimate of needs.
- States provided better data to the survey than previously because they realized that it would be the basis for allocating construction grant funds.

Industrial Costs.

Nonthermal Costs. The 1972 Amendments require industries to use "best practicable" water pollution control technology by mid-1977 and "best available" technology by mid-1983.

The emphasis in this report is on the costs industry will incur in meeting the 1977 standards.

The highest estimate of treatment costs indicates industry (except power plants) will have to invest an additional $11.9 billion (1972 dollars) by 1977 to achieve pollution abatement standards set for that year. Total investment, including capital now in place, will amount to $18.7 billion. At this level of investment, total annual costs, including operation and maintenance, will be $4.5 billion.

The total investment may not be as great as $11.9 billion, however, because this estimate assumes that there will only be moderate reduction of wastewater flows and that all abatement will be achieved by end-of-the-line treatment. Requiring treatment of wastewater may lead industry to switch to processes that use much less water, resulting in lower control costs. Equally important, industry can change its raw materials, manufacturing processes, or products, and, as a result, achieve the same degree of abatement at less cost than end-of-the-line treatment.

The $11.9 billion estimate is greater than the $8.1 billion in the *1972 Economics of Clean Water* because:

- Costs are based on the 1977 standards rather than the earlier industrial wastewater guidelines.
- The industry sample is larger—148,000 plants using in excess of 1 million gallons per year rather than 14,500 plants using in excess of 10 million gallons per year.
- The costs of controlling pollution from animal feedlots is included.
- Growth rates are projected for each industry, rather than using the average growth rate for all industry.
- The costs are in 1972 rather than 1971 dollars.

In 1972, industry (excluding animal feedlots, lumber, and leather) invested about $1.0 billion in water pollution control facilities, which is much less than appears to be needed to meet the $11.9 billion estimate of needed investment. If industry adopts less costly control options, of course, the current level of investment may be closer to what is adequate.

Thermal Costs. Utility steam-electric power plants account for almost 80 percent of the water used for cooling and condensing purposes in the United States. The capital expenditures required to meet the 1977 standard for this source of pollution are estimated at $2.3 to $9.5 billion; the 1983 standard will require $4.4 to $15.3 billion, depending upon water quality exemptions provided by Section 316 of the 1972 Amendments.

The estimated increase in the price of electricity will be 0.8 to 3.2 percent for meeting the 1977 water quality standards and an additional 0.9 to 2.9 percent for meeting the 1983 water quality standard depending upon the number of exemptions.

Costs of thermal pollution control were not developed for other industrial segments primarily because of the difficulties of estimating the costs of controlling thermal discharges from in-house electric power generation and a myriad of industrial processes.

Nonpoint Source Pollution. The agricultural sector is estimated to have the productive capacity to meet food and fiber demands to the year 2000 while taking measures to reduce pollution by soil loss from erosion and by nitrogen fertilizers. To maintain agricultural production under a program limiting soil loss, conservation practices such as contouring, strip cropping, and terracing would have to be adopted. Crop production would also have to be shifted to more productive soils and regions. The impacts would be minor on the use of the Nation's land and water resources and on farm prices, but soil erosion would be reduced considerably. Similarly, a nitrogen fertilizer limitation program could be implemented by substituting land and water for fertilizer. There would, however, be some increase in farm prices.

The environmental protection measures required might be the basis of a new supply restriction program. The lower productivity resulting from environmental restrictions may have the same effect on total supply as the recently reduced Federal cropland restriction program, and may cost approximately the same as payments under the recently reduced program.

Setting limits on soil loss and nitrogen application would not reduce total national farmer receipts if two conditions were met. First, the level of production must not be lower than under the land retirement programs. Second, the farm community must receive payments equal to what it formerly received for removing land from production. However, the environmental limits would have greatly varying effects on farmer receipts in different farm regions.

Types of Benefits From Water Quality Enhancement. Several sections of the 1972 Amendments require the use of formal cost/benefit analysis. Among them is the requirement for cost/benefit analysis in cases where effluent limits are more stringent than those provided for by best available technology.

The objective of benefit analysis is to indicate the economic value of the cleaner environment resulting from projects that abate water pollution. Unlike the value of most goods and services, the value of activities resulting from improvements in water quality are, for the most part, not indicated by market prices. Instead, the value must be imputed indirectly by analyzing the effect of improved water quality on the costs of producing or consuming goods, on the enjoyment of water-related activities, or on human health.

Water quality is important in industrial uses, municipal (domestic) water supplies, agriculture, and commercial fisheries. When the quality of water is improved, water treatment costs of industrial and municipal users is lower. In agriculture and commercial fisheries improved water quality means increased net income resulting from the increased production.

Water quality is important in enhancing the enjoyment of recreation. The value of water is the increased willingness to pay for the water-related recreation experience.

Water quality is important as a factor in human health. At this time there has been little research on the economic valuation of reduced health hazards or the willingness to pay to avoid the risks associated with water pollution.

While the report concentrated on the problem of assigning a value to changes in water quality, valuation is only the last step in estimating a particular benefit. The procedure requires four sequential steps:

- The abatement plan must be specified in terms of amounts and types of pollutants to be reduced.
- The impact of the controlled pollutants on water quality parameters must be estimated.
- The impact of changes in the parameters on water uses must be estimated.
- The economic value of induced changes in the level of uses, the increased value of existing uses, and the cost savings resulting from improved water quality must be identified.

The greatest difficulties lie in the second step, of tracing the effects of pollutants on water quality parameters, and in the third step, relating parameter changes to man's use of the water or adjacent shoreline. To a large extent, improved benefit analysis depends on better knowledge of how to measure these two relationships.

Constraints

Fiscal Impact on Local Government. The construction of municipal sewerage systems required by the 1972 Amendments will result in capital expenditures by all levels of government. A projection has been prepared of possible outlays during 1974-1980. It relies heavily on two assumptions: State and local governments will not invest independently of Federal funding, and the $18 billion authorized in the 1972 Amendments will be alloted for use in FYs 1973-76. (The actual rate of allotment may be different depending on fiscal policy.)

The total Federal, State and local cash outlay resulting from these assumptions, and from previous outstanding obligations, would total $33.8 billion between 1973 and 1980. Of this total $12.9 billion would be provided by State and local governments. The projected annual cash outlay of approximately $2 billion is almost twice the amount State and local sources supplied in 1970 to build sewerage facilities.

Local governments will probably finance their portion of the projected capital expenditures through a variety of sources, including current general revenues and the issuance of municipal bonds. Several recent reports have indicated that State and local governments may run surpluses in their current general accounts over the next several years. Such surpluses would give States and localities greater flexibility in financing construction projects.

Should localities continue to sell bonds to finance approximately two-thirds of their investment in sewerage construction, sewer bonds will continue to represent just over 5 percent of the overall municipal bond sales. Municipalities should encounter no difficulties in selling such bonds. The market for bonds has improved since the late 1969 credit gap in spite of a generally tight credit market. If another major credit gap occurs, municipalities should be able to temporarily substitute short-term for long-term bonds as they did in 1969-70. Nor do credit limitations seem to offer a serious constraint. Municipalities have demonstrated that, in most cases, they can avoid these restrictions by such measures as issuing revenue bonds, shifting financial responsibility to independent authorities, and using lease purchase arrangements. Despite this generally optimistic picture, individual localities may find financing a major problem, perhaps because of unacceptable credit ratings. Some should be able to obtain financial assistance from State construction grant programs; others should be able to sell their bonds to the newly created Federal Environmental Financing Authority or obtain loans, if they have a population under 10,000, from the Farmers Home Administration.

As a direct result of the projected increase in capital expenditures, the annual cost for localities to provide sewerage services may increase by 66 percent in the next 4 years. This should be viewed against an expenditure on sewerage operations amounting to 1 percent of all current local expenditures in 1970. The increase due to capital expenditures on sewerage would increase the cost of sewerage operation to 1.7 percent of the 1970 level of expenditures.

Economic Impact of Industry. An overview of 23 industries discharging directly into the Nation's waters indicates that in most cases they will be able to recover the costs of best practicable wastewater treatment by increases in prices. However, individual plants in certain industries will experience difficulties in meeting the requirements. Generally, the profitability of smaller and/or older plants may be so reduced by pollution control that many of them may decide to close prior to 1977. Secondly, plants located in heavily urbanized areas, especially small older ones, will experience difficulties because they lack the necessary land to use the most cost-effective treatments. In the absence of adequate municipal treatment facilities the 1977 requirements may force many of these plants to close, relocate elsewhere, or be absorbed by more viable firms.

Most of the industries studied are expected to raise prices (regardless of potential closures) with the size of the increase varying among segments of an industry (Table VII-10). The industries expected to experience prices increases of less than 1.5 percent are *asbestos*, dairies, feedlots, *flat glass*, leather, meatpacking, *nonferrous metals*, softwood plywood, and wood preserving. Price increases of 1.5 to 5 percent are expected to occur in *cement*, *fertilizer*, fiberglass, fruits and vegetables, and hardwood plywood. Price increases higher than 5 percent are expected in electroplating, *hardboard*, *inorganic chemicals*, *organic chemicals*, *paper*, plastics, and *synthetics*. (The industries italicized also face significant air pollution control costs.)

Pollution control costs that cannot be passed on in the form of price increases will result in decreasing profit margins and, in some cases, plant closings. Plant closings are expected in all of the industries with the exception of cement, flat glass, ferroalloys, fiberglass, grain milling, and rubber.

In most of the industries studied, closings will be due primarily to factors unrelated to water pollution control costs, but they will be accelerated by these costs. Dairies, feedlots, fruits and vegetables, and leather are examples of industries in which plant closings will occur unrelated to pollution control expenditures. The maximum direct unemployment would be about 50,000 or 1.5 percent of the estimated total employment in the industries studied of 3.3 million.

Construction Industry Capacity. The increased construction called for by the 1972 Amendments—$8.9 billion in 1976 compared to $3.0 billion in 1971—will place additional demands on the capacity of the construction industry. EPA initiated several studies to assess the impact of these incremental expenditures on the price and quantity of all construction and on each of five sectors of the construction industry. In addition, several of the studies examined the possible existence of specific bottlenecks, such as the supply of skilled labor or entrepreneurs, that would limit the construction industry's capacity to meet these demands.

Assuming a generally homogeneous construction industry, these studies suggest that the industry can meet the demands. However, specific localities may have insufficient capacity to carry out large scale projects. The $4.9 billion incremental increase (1976 peak year) over the baseline estimate in wastewater treatment construction would raise overall construction prices by only 0.6 percent.

According to the models of EPA and others, factors such as the level of economic activity, government expenditures, and the rate of interest are more important than prices in influencing demand. In the case of interest rates EPA found no evidence to suggest that an increase, induced by pollution-related construction activity, will be as much as 1 percent of the current level.

The studies indicate that the level of activity in other sectors of the construction industry will be reduced by an increase in pollution-related construction. A $4.9 billion increase in EPA-stimulated demand over the baseline estimate for sewer construction is projected to decrease other construction by less than $0.3 billion. The private residential sector will likely absorb approximately one-third of the reduction. The public non-building sector is likely to absorb a significant portion as well. However, these results may be affected by past policies of using public works projects to smooth the overall level of construction activity.

The analysis did not examine the determinants of price increases that are unrelated to changes in construction demand. EPA recognizes, for example, that the recent devaluation has increased the demand for exports (e.g. a larger European demand for U.S. steel reinforcing rods) and that this change will increase the domestic price of construction and result in some shortages. Similarly, EPA recognizes that uncertainty about future prices and deliveries of inputs in the construction process can result in significant increases in the price of construction as supported by recent evidence.

Equipment Supply Capacity. Industries supplying water pollution control specialty equipment and instrumentation appear to have the long-term production capacity to meet the projected demand. A 1972 analysis of capacity, based on statements of equipment suppliers and secondary statistics, found that:

- The profit margins enjoyed by pollution control companies on their pollution business have generally exceeded the margins on their other business in the same industrial categories.
- Companies in which pollution control is a significant activity (greater than 5 percent of sales) have a slightly higher return on assets than companies in which pollution control is a minor activity.
- Comparing the returns on assets, companies "in" the pollution control business have out-performed those in closely-related industries.

In recent years, the municipal sector's demand for pollution abatement equipment has grown only 0.6 percent per year. This plateau of demand developed primarily because municipalities waited for promised Federal assistance. The demand is expected to accelerate because of expenditures in 1974-1976, and to taper off through 1980. The specialty equipment segment of the industry is expected to grow at a higher rate—14.1 percent per year in 1973-1975 and 9.5 percent per year in 1975-1980. Similarly, the growth of the instrumentation segment is expected to be high—17.9 percent for the first period and 15.9 percent for the second.

Demand from the industrial sector is expected to increase modestly through 1977 and then drop substantially through 1980. Again, specialty equipment expenditures will grow at a faster rate than total expenditures, because of a trend toward advanced treatment.

The above analysis assumed that the raw material and skilled labor inputs would be available to complement the productive capacity. Recent evidence suggests that they might be in short supply in some localities.

CONCLUSIONS

The economic factors examined, other things being equal, will not in EPA's view significantly constrain the accelerated program launched by the 1972 Amendments to control pollution from municipal and industrial sources. In particular:

- Local governments will have adequate general revenue or municipal bonding capability to finance their share of building sewerage systems. The combination of the State grant/loan programs, the U.S. Environmental Financing Authority and the Farmers Home Administration loan program should be able to deal with an individual municipality with a financial problem.

- An overview of 23 industries discharging directly into the Nation's waters indicates that in most cases they will be able to recover the costs of best practicable wastewater treatment by increases in prices. However, individual plants in certain industries will experience difficulties in meeting the requirements. Generally, the profitability of smaller and/or older plants may be so reduced by pollution control that some of them may decide to close prior to 1977.

- The results of econometric models indicate that the construction industry should be able to build the required facilities with real price increases of less than 1 percent attributable solely to EPA-stimulated demand, assuming resource transferability within the construction industry. The skilled labor needed should be available to meet peak-year requirements with some impact on wages. In some localities, the construction industry may lack adequate short-term capacity, especially in light of the changing nature of the economy.

- The pollution abatement equipment industry is attractive enough to encourage the growth and development of long-term supply. Production capacity as estimated in 1972 is not viewed as a constraint. However, raw material and skilled labor inputs may be a constraint in some cases.

Other things being equal, the economic factors examined will not be serious constraints in meeting effluent standards. (However, the other things assumed equal may not be equal. Unforeseen events such as the energy crisis or devaluation of the dollar may lead to basic changes in the system, and, therefore outcomes may differ from those predicted.) Other factors, such as budget constraints both in the public and private sectors and legal and administrative steps that must be taken in controlling wastewater discharge could account for delays.

As long as there are significant non-point sources of pollutants, control of industrial and municipal sources does not mean that all areas of the Nation will have clean water at the same time. A fundamental question remains: At what point do the additional costs of controlling all sources of pollutants exceed the additional benefits of improved water quality? Clearly, the current societal concern for environmental quality indicates that the public believes there are significant benefits yet to be attained.

II. Nature of and Trends in Water Pollutants

INTRODUCTION TO POLLUTION PROBLEMS*

No one has described completely the quality of a body of water. To do so would entail chemical analyses of a near-infinite number of solid, liquid, and gaseous compounds, as well as a complete identification of all biota present in the water from viruses to vertebrates. Thus, any practical description of water quality can only be concerned with a very limited subset of all conceivable physical, chemical, and biological aspects of actual waterbodies. Typical water quality measurements are, in fact, oriented toward a small group of commonly observed pollution problems.

Harmful Substances. A stream of seemingly clean and pure water may be highly polluted due to the presence of toxic substances in very low concentrations. For example, certain chemicals in concentrations of only several parts per billion may be deadly to the mayfly, an important link in the aquatic food chain. Certain harmful substances may be natural such as acids from bogs. Most, however, are man-made such as industrial and agricultural chemicals. A few of these are well known—heavy metals, pesticides, herbicides, and polychlorinated biphenyls (PCB's), for example.

Toxicity effects can be dramatic, as in the case of large fishkills, or they can be subtle, as in the case of minute concentrations causing decreasing fertility or changing reproductive or predation habits over a long period of time. Detecting any chemical and tracing it back to its sources can be difficult, particularly in the case of widely used and highly persistent substances such as mercury, dieldrin, or PCB's. Sources can be diverse, ranging from industrial or municipal sewage discharges to urban stormwater, agricultural runoff, or atmospheric particle "fallout". It is therefore not safe to assume that the only major sources of harmful substances are industrial discharges.

Analysis of these harmful substances is complicated because they do not usually remain dissolved or suspended in water but are taken up by sediments, plants, and animals. In the case of DDT, concentrations in fish will be at least one order of magnitude greater than in sediments, which in turn have concentrations at least one order of magnitude greater than the overlying waters. Since most other important pesticides are insoluble (and many toxic metals form insoluble salts), water concentrations by themselves do not form reliable indicators. For the same reasons, water concentrations will tend to be very low—on the order of parts per billion—making results extremely sensitive to the specific chemical analysis methods used. For instance, older gas chromatographic methods for DDT were unable to distinguish DDT clearly from PCB's. Since PCB's are often found in substantially higher concentrations than DDT, these older results are quite unreliable.

Physical Modification. Aquatic habitats are sensitive to fluctuations of many physical characteristics of water including temperature and transparency. Temperature fluctuations occurring naturally can be amplified by human activities through large discharges of industrial cooling water, such as from power plants or steel mills, from release of warm surface water held in reservoirs, or from destruction of shade trees along stream banks. Warm discharges do not automatically cause ecological damage—some increase desirable biological activity. Large thermal discharges into small or relatively stagnant bodies of water, however, can cause large temperature increases. If such increases occur in critical "zones of passage" or spawning grounds, they can disrupt important biological communities.

Natural waters lose transparency due to sediment loads. Aside from natural sources of sediment there are human sources including construction activities, strip mining, and farming practices. Transparency can also be lost by excess microorganism growth stimulated by nutrient-rich agricultural runoff, urban stormwater or sewer overflows, and sewage treatment plant discharges. Reduced transparency has a serious effect other than aesthetic degradation: It reduces the amount of light available to underwater plants and thus decreases a primary food source for certain fish and birds.

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*Most of the information presented in this introductory section was prepared by Enviro Control, Inc.

Another significant alteration of key aquatic habitats results from physical modification of shores, banks, and channels. Artificial draining of marshland to create waterfront property destroys the highly productive environment necessary for spawning of certain fish species and feeding of migratory birds. Construction of breakwaters can reduce "flushing" of bays to the point where the effect of pollutant discharges to these bays is greatly magnified by stagnant water conditions. Channel and watershed "improvement" destroys biological communities on stream banks and, in some cases, can accelerate erosion and sediment.

Finally, dams and their impoundments can produce profound changes in the physical and biological characteristics of a stream. These changes include beneficial as well as negative effects.

Not all aspects of physical modifications of streams and estuaries are quantifiable. In fact, only a few simple measures of the extent of harmful physical modifications (including suspended solids, turbidity, color, and temperature) are known. Some other physical measures that would be useful are often not routinely made; among these are sediment cores to analyze the nature of bottom deposit buildup, and settleable solids to measure the materials deposited on the bottom.

Eutrophication. An adequate crop of algae is the beginning of the food chain for most aquatic communities. However, relatively stagnant waters (such as lakes and slow-moving estuaries) rich in nutrients can grow such heavy crops of algal and other aquatic plants that the decay of dead cell matter may seriously deplete the bottom waters of oxygen. This prevents the survival of oxygen-sensitive food species and fish. In extreme cases floating algal mats, thick bottom slimes, and odors result.

There are many waters in the nation that are or were naturally eutrophic. On the other hand, artificial addition of any one of the 100 or so nutrients necessary to plant growth may stimulate algal blooms (heavy growths) in stagnant waters where that nutrient is normally undersupplied. In addition to the well-known nutrients, phosphorus and nitrogen, there are others equally essential to plants, including carbon dioxide, potassium, magnesium, and vitamin B-12. Man adds nutrients to water by many means. Perhaps one of the most important sources is runoff of agricultural fertilizers, which yield large loads of phosphorus, nitrogen, and potassium; other sources include treated municipal sewage, industrial discharges, and sewer overflows.

The only direct measure of eutrophication is a complete biological study of the waters in question. Indirect measures of eutrophication are biomass, standing algal crops, chlorophyll, nutrient uptake and benthic (that is, stream or lake bottom) oxygen demand. Unfortunately, most of these are almost never monitored routinely. Nutrient levels can be useful, although not necessarily conclusive measures of the potential for eutrophication. Of the 100 or so nutrients essential for plant growth, only compounds of nitrogen and phosphorus are routinely measured, making it difficult to use normal monitoring evidence to specify either nitrogen or phosphorus as the direct cause of a bloom.

Salinity, Acidity, and Alkalinity. Major changes in the salt content of water can seriously disrupt aquatic communities and decrease the value of water for irrigation and water supply purposes. Where the fresh water inflow of estuaries is reduced through upstream consumption or diversion of freshwater, the saline front advances upstream. This advance decreases the low salinity area of the estuary necessary for spawning or growth of important species such as striped bass. Many inland streams are naturally saline, due to the salt content of solids and minerals in their drainage basins. In certain areas, this natural salinity has been substantially increased by man's activities. Irrigation in saline soil areas increases stream salinity, because of increased evaporation (both on land and in reservoirs) and leaching of salt from the soil into the irrigation return flow. In certain basins, mine and quarry drainage can also add substantial salt loads to rivers.

Acidity changes can be equally damaging to aquatic life. The most important acid sources are drainage from mines and acid rain downwind from major sulfur-polluted air regions. The importance of sulfur air pollution has only recently been recognized; several small lakes have suffered such serious increases in acidity within only one decade as to almost eliminate many desirable fish species. Highly acidic industrial and municipal discharges that are large relative to the receiving stream can also cause damage.

Alkalinity presents problems in many areas, particularly west of the Mississippi River. The problems range from reduced agricultural production to the fouling of water pipes. Most alkaline pollutants are from natural sources such as sodium carbonate deposits. However, certain industries such as the gypsum board industry may also contribute to an alkaline condition.

Quantitative analysis of salinity normally uses total dissolved solids as an indicator of total salts; common individual salts such as sulfates and chlorides are also sometimes measured. To some extent, specific ecological damage due to salinity depends on the composition of the salts present. Acidity/alkalinity measures are considerably more complex. pH, the measure of free hydrogen ions present, measures the stream's capacity to neutralize or "inactivate" bases. Alkalinity measures the stream's capacity to buffer acids. Thus, if a given stream shows little pH trend over the last 10 years, but alkalinity has decreased markedly, one can predict that the stream will be considerably more vulnerable to relatively small acid discharges.

Oxygen Depletion. Oxygen dissolved in water is one of many substances essential to sustaining aquatic animal life. The dissolved oxygen (DO) level is widely considered to be the single most important indicator of pollution; actually, there is no reason to consider it more or less important than indicators such as toxicity, salinity, and algal population.

Dissolved oxygen is consumed whenever any substance is oxidized in water. This oxidation can be a direct chemical process or it can be a biological process. All aquatic animals, from bacteria to fish, consume dissolved oxygen in metabolizing food substances. Such food substances range from sugars and starches, which are consumed by microorganisms in days, to paper pulp or oils, which are consumed by microorganisms only after months. Rapidly consumable substances create oxygen deficits within a few days of stream travel from their sources, while slowly consumable substances create deficits weeks or months of stream travel away from their source.

Thus, slowly consumable substances may not cause significant oxygen loss in the stream at all; instead, they may be consumed in a downstream lake, reservoir, estuary, or ocean where they may or may not pose a problem. Naturally, the rate of consumption for a specific food substance or waste is highly sensitive to temperature; higher water temperatures greatly accelerate the growth and metabolism of the microorganisms that feed on the waste. On the other hand, many toxic substances slow this growth and can give a misleading picture of oxygen sufficiency.

Oxygen-consuming or oxygen-demanding substances can be attributed to many sources. There are large natural sources, including leaves, soil organic matter, and wildlife droppings washed into rivers by storm runoff. Agricultural areas contribute additional runoff-carried oxygen demand from lifestock manure and topsoil erosion. There are also the classical "point" sources: municipal sewage treatment plant discharges and a wide variety of industrial waste discharges. However, some urbanized areas contribute oxygen-demanding loads by other routes including storm sewers, sewer overflows, intentional treatment plant bypasses, sewer leaks, and unsewered runoff.

The direct quantitative measures of oxygen content of water are the absolute concentration of DO present, and the percent of saturation for DO corrected for temperature and pressure (since warm or low pressure water can dissolve less oxygen than cold or high pressure water). The latter measure is based on theoretical tables of saturation values for dissolved oxygen in distilled water, but many substances found in impure water can either raise or lower saturation levels of DO. Supersaturated values of up to 140 percent are seen, particularly in waters where algae contribute substantial oxygen.

In describing the oxygen-depleting characteristics of wastes, 5-day biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) are the most common measures. In BOD_5, the waste or stream sample is incubated in a bottle (sometimes inoculated with stream microorganisms) at 20°C. for 5 days, and the weight of oxygen metabolically consumed by the microoganisms is measured. Among the many deficiencies of the BOD_5 measurement are: It has very poor repeatability; bottle conditions are far from stream conditions; trace toxicants can seriously inhibit microorganism growth and reduce apparent oxygen demand; and the 5-day reading gives no indication of depletion rate over shorter or longer peiods. In measurement of COD, a sample of water is chemically oxidized to give an approximate upper bound on the amount of biologically oxidizable material present; COD cannot be measured in salty water, however, and it also fails to capture volatile oxidizable substances such as organic acids, alcohols, and ammonia.

Health Hazards and Aesthetic Degradation. An assessment of health hazards from polluted water involves considerable uncertainty. There is little doubt that human feces carry infectious pathogens for a number of intestinal diseases, typhoid fever, hepatitis, brucellosis, encephalitis, poliomyelitis, psittacosis, and tuberculosis. However, there are grave uncertainties about the die-off rates of pathogens in natural waters as well as their infectiousness for swimmers or other recreational water users. Note that the issue of drinking water is not at stake, since its safety depends on disinfection treatment by the water supply system. The evidence that water polluted with fecal matter can transmit diseases to swimmers is sparse and uncertain, particularly since it has been discovered that swimmers in unpolluted water also have higher incidences of common ear, eye, and nose infections. There is some evidence that hepatitis can be transmitted via shellfish from polluted waters; unfortunately, the usual antibacterial measure—chlorination of sewage effluents—may not abate this problem for viral forms of hepatitis.

The evidence for waterborne toxicity hazards via fish, shellfish, and perhaps drinking water is somewhat stronger, at least in the case of relatively high concentrations of mercury and cadmium. On the other hand, considerably less effort has been expended on the chronic health hazards of low-level, long-term toxicants in drinking water (and fish) than on the infectious disease problem. Consequently, little can be said in this area, since even monitoring data are sparse.

Despite the paucity of evidence regarding waterborne transmission of diseases to recreational users, public health agencies since the turn of the century have assumed that the problem exists. Because of the expense of direct identification of specific pathogens in water, these agencies traditionally have used several indirect and nonspecific measures of bacterial populations in water: total coliforms, fecal coliforms, and fecal streptococci. These bacteria are not pathogenic, nor do they simulate the die-off rates of pathogens. Fecal bacterial counts are good indicators of the presence of undisinfected municipal sewage, when runoff sources are either low or insignificant. Unfortunately, fecal coliforms are also found in runoff from agricultural and wilderness lands and from urban areas. In fact, it is possible that fecal coliforms can multiply significantly in streams under certain conditions.

Water bodies can be degraded aesthetically by increases in murkiness, color, algal scums, floating solids and oils, and odors. Murkiness is approximately measured by turbidity, which has been discussed, together with color, under Physical Modifications. Algal growth has been discussed under Eutrophication. Floating solids and oils, in areas with properly functioning treatment plants and oil separators, generally come from combined sewer overflows, storm sewer discharges, and unsewered runoff, as evidenced by the major increases in these measures directly after rainstorms. Unaesthetic odors can stem from many sources, including decaying organic matter in water or on the bottom and a myriad of industrial chemicals. Among chemicals, phenols are traditionally singled out for special attention by pollution control agencies.

In the broad area of health hazards and aesthetic degradation, only a few measures are routinely monitored. The ones available for analysis are total coliform, fecal coliform, fecal streptococci, phenols, and odors.

STATUS OF WATER QUALITY

EPA's analysis of 22 major rivers, contained in the *1973 National Water Quality Inventory Report*, sheds some light on the kinds of pollution requiring control and on recent trends.

The 22 rivers, ranked from "cleanest" to "dirtiest" in Table II-1, were selected for study because of their length, flow, and proximity to large cities. This ranking of reaches on the 22 rivers is not necessarily complete or fully accurate for all purposes. For example, ranking is based only on physical modification, nutrients, eutrophication, acidity, salinity, oxygen, and health parameters. Effects of metals and pesticides are not included, because data were not complete at the time this report was prepared. The analysis does not incorporate biological or other measures because data are less readily available and reference levels are not clearly defined.

Detailed analyses of the 22 rivers as a whole show that the worst readings and trends were for nutrients (Table II-2). The pollutants receiving the most widespread controls (bacteria and oxygen demand), however, were improving. The analyses indicated that:

- For nutrients, up to 54 percent of the reaches exceeded EPA's phosphorus guidelines set to protect against potential eutrophication in flowing streams. Up to 84 percent of the reaches showed increased phosphorus levels in 1968-1972 over the previous 5 years. Nitrogen nutrients, while generally not exceeding reference levels, increased in up to 74 percent of the reaches measured.
- Other pollutants with high levels were phenols (industrial compounds which can taint fish flesh and cause taste and odor problems in drinking water) and suspended solids (which interfere with some aquatic life processes). These results are not as disturbing as the nutrient data, because in up to 80 percent of the reaches with data, phenols and suspended solids improved in the last 5 years.
- The pollutants receiving the most widespread controls, bacteria and oxygen demand, showed general improvements in the last 5 years. Dissolved oxygen and oxygen-demand levels improved in up to 72 percent of reaches; bacteria up to 75 percent.

Five of the rivers were studied in greater detail: the Mississippi, Missouri, Ohio, Tennessee, and Columbia Rivers.

Mississippi River. Based on routine monitoring data available to EPA for the years 1963-72, the most significant types of pollution for the Mississippi River are the presence of undesirable bacteria throughout the river (noticeably around urban centers). Special studies confirmed the

TABLE II-1

POLLUTION RANKINGS OF 22 MAJOR U.S. RIVERS*

(Preliminary)

Best Third	Middle Third	Worst Third
Upper Missouri	Rio Grande	Lower Red
Columbia	Alabama	Hudson
Snake	Upper Ohio	Lower Ohio
Willamette	Upper Red	Lower Mississippi
Upper Mississippi	Brazos	Lower Arkansas
Yukon	Potomac	Middle Ohio
Tennessee	Upper Colorado	Mississippi near Minneapolis
Susquehanna	Middle Mississippi	Lower Missouri
Lower Colorado	Sacramento	Upper Arkansas
		Middle Missouri

*From 1968-72 STORET data; rankings based on the number of pollutants registering median values higher than uniform national reference levels.

Source: 1973 Water Quality Inventory Report to Congress. EPA.

TABLE II-2

WATER QUALITY TRENDS FOR 22 MAJOR RIVERS
(1963-72)
[Preliminary]

Parameter	Readers analyzed	Trends of reaches from 1963-67 to 1968-72			% of reaches exceeding reference levels		
		Improved	Worse	% Improved	1963-67	1968-72	Change
Suspended solids	24	20	4	83	30%	16%	−14%
Turbidity	27	21	6	78	30	32	+2
Temperature	29	20	9	69	0	0	0
Color	27	7	20	26	No reference level used		
Ammonia	21	16	5	76	14	4	−10
Nitrite	5	2	3	40	No reference level used		
Nitrate (as N)	13	0	13	0	0	0	0
Nitrate (as NO_3)	19	5	14	26	No reference level used		
Nitrite plus nitrate	24	8	16	33	0	0	0
Organic nitrogen	8	4	4	50	No reference level used		
Total phosphorus	25	4	21	16	35	54	+19
Dissolved phosphate	16	8	8	50	8	25	+17
Total phosphate	13	6	7	46	30	37	+7
Dissolved solids (105°C)	24	16	8	67	29	21	−8
Dissolved solids (180°C)	23	14	9	61	28	12	−16
Sulfates	30	16	14	53	13	13	0
Chlorides	30	18	12	60	13	10	−3
Alkalinity	29	12	17	41	No reference level used		
pH	30	16*	14*	53	0	0	0
Dissolved oxygen	27	17	10	63	0	0	0
BOD_5	27	19	8	70	0	0	0
COD	18	13	5	72	No reference level used		
Total coliforms (MFD)†	21	14	7	67	26	14	−12
Total coliforms (MFI)†	9	4	5	44	56	30	−26
Total coliforms (MPN)†	9	6	3	67	25	21	−4
Fecal coliforms (MF)†	5	3	2	60	60	21	−39
Fecal coliforms (MPN)†	4	3	1	75	17	43	+26
Phenols	7	5	2	71	82	69	−13
Odor	4	2	2	50	No reference level used		

*For pH, read "less acidic" for "improved"; read "more acidic" for "worse."

†Membrane filter delayed, membrane filter immediate, most probable number, membrane filter.

presence of phenols downstream from cities and industrial complexes. Phenols cause taste and odor problems in drinking water and prevent commercial fishing in several large river segments.

- *Harmful Substances*. Phenol levels below St. Louis and Baton Rouge are probably major reasons that commercial fishing has been eliminated in these two areas.
- *Physical Modification*. The upper river below Minneapolis-St. Paul shows increased levels of BOD_5, ammonia, and nitrates; turbidity and solids are increased downstream from the Missouri River.
- *Eutrophication Potential*. Limited data are available to assess eutrophication directly. However, phosphorus levels have increased in the lower river (below Ohio River) in the recent 5 years while the upper river remains unchanged. Below Minneapolis-St. Paul, there are significant increases of ammonia and nitrates. Enough phosphorus and

nitrogen are present to support nuisance algae growths in this area, and levels are generally getting worse.

- *Salinity, Acidity, and Alkalinity.* The only noticeable changes occurred below the inflows of the major tributaries. For example, increases in dissolved salts, particularly sulfates, were detected below the Missouri River. Alkalinity dropped below Cairo because of the acidic inflow from the Ohio River.
- *Oxygen Depletion.* Dissolved oxygen levels are satisfactory throughout the river except below Minneapolis-St. Paul. BOD_5 and other parameters associated with sewage and industrial wastes indicate that urban areas are the primary sources of pollutants. Most of the river has improved in the last 5 years, with a significant improvement below Minneapolis-St. Paul due to secondary treatment of municipal wastes.
- *Health Hazards and Aesthetic Degradation.* Fecal coliform counts are exceeding recommended standards throughout the Mississippi River, with peaks below urban centers, especially below Minneapolis-St. Paul. These levels are considered excessive for primary contact recreation use.

Missouri River. According to the 1963-72 data, the most significant types of pollution in the Missouri appear to be physical degradation (primarily related to erosion), and potential health hazards. Special studies confirm the presence of undesirable bacteria and viruses and tainting of fish flesh downstream from several large cities. These problems appear to come from sewage treatment facilities, but they are overshadowed up to 16 percent of the time by pollutants that are associated with runoff during heavy rains.

- *Physical Modification.* The middle and lower portions of the Missouri experience some of the heaviest sediment erosion in the United States, producing high suspended solids and turbidity. While much of the erosion is natural, pollutants washed from farms and cities are carried with the soil, and add to the organic matter (BOD_5, COD, and ammonia), nutrients (phosphates and nitrates), and salts (sulfates) in the river, particularly after rainfalls.
- *Eutrophication Potential.* Limited data are available to measure the potential of eutrophication directly. However, enough phosphates and nitrogen are present in the middle and lower Missouri to support nuisance algae growths, and levels were generally worsening over the 1963-72 period.
- *Salinity, Acidity, and Alkalinity.* Dissolved salts, particularly sulfates, reach and often exceed national guidelines for water supply intakes in the middle and lower Missouri.
- *Oxygen Depletion.* Organic loadings in the Missouri are high, in part due to heavy animal feedlot runoff from Kansas, Nebraska, and Iowa. At times these loadings have been sufficient to deplete dissolved oxygen below recommended levels for fish. BOD_5 and COD improved near large cities in the last 5 years compared to the preceding 5 years.
- *Health Hazards and Aesthetic Degradation.* Fecal coliform levels peak well in excess of water quality standards for swimming and drinking downstream from urban areas in both wet and dry periods, as do other measures of fecal contamination and viruses. Point sources are probably responsible for most of the pollution, but conditions also generally worsen after rainfalls, reflecting nonpoint sources of pollution.

Ohio River. Based on 1963-72 data, the most serious problems in the Ohio River are: elevated bacteria levels near cities; acidity from mines and industries; the potential for eutrophication; and suspended solids. Field studies indicate that if industries and municipalities adhere to effluent limitations, the Ohio can meet standards for fish and, in some areas, for swimming by 1977. However, potential eutrophication and sediment runoff may continue to be problems.

- *Harmful Substances.* Monitoring data show high levels of iron, in all four sections of the river, with trends toward higher levels in the last 5 years. Special studies show industrial oil, scum, foam, phenols, and other chemicals affecting areas near Pittsburgh, Huntington, Marietta, and Parkersburg. Biological studies confirm the presence of toxic materials near Pittsburgh. Downstream, the river shows recovery, and some improvements have been noted since 1970.

- *Physical Modification.* High levels of suspended solids occur in the lower Ohio, primarily during high flows. In some portions of the river, the levels are markedly improved compared to 5 to 10 years ago.
- *Eutrophication Potential.* Indirect evidence suggests that biological activity is being heightened in the presence of enough nitrates and phosphates to support nuisance algae growths, although such growth has not been observed. Nutrients have not changed significantly in the last 10 years.
- *Salinity, Acidity, and Alkalinity.* At 11 of 40 stations, the river is occasionally more acidic than permitted by standards. Most of this may be attributed to acid mine drainage from upstream tributaries.
- *Oxygen Depletion.* Two stations report dissolved oxygen problems. Pittsburgh's and Cincinnati's municipal discharges are known to be producing low dissolved oxygen at times.
- *Health Hazards and Aesthetic Degradation.* In summer, total and fecal coliforms exceed permissible levels at Cincinnati and Louisville. Special studies show bacterial levels improving in the past 5 years near other cities.

Tennessee River. Data from 1963-72 indicate that the most serious potential problem on the Tennessee River is the increase in nutrient levels in the nine mainstream reservoirs. Other problems are the presence of high bacteria levels in the reservoirs near cities and low dissolved oxygen levels in dam releases. Nitrogen and phosphorus concentrations in the reservoirs are high enough to encourage some undesirable algae growth; nitrates, in particular, are high in all reservoirs and increased significantly during the last decade. In general, however, the Tennessee River and its reservoirs do not show widespread pollution and are among the cleaner waters studied in the 22 rivers.

- *Eutrophication Potential.* Nitrogen and phosphorus concentrations in the nine mainstem reservoirs are no longer limiting aquatic growth. The seasonal pattern of nutrients suggests that biological activity is increasing, although nuisance algae has not been noted. Nitrate levels are quite high in all nine reservoirs, with significant increases over the 10-year period. Maximum concentrations occur primarily during periods of high flows. Organic nitrogen and ammonia are also increasing.
- *Oxygen Depletion.* The water released from some reservoirs during the summer months is low in dissolved oxygen due to thermal stratification.
- *Health Hazards and Aesthetic Degradation.* During several months each year, fecal coliforms exceed permissible levels for contact recreation and drinking water.

Columbia River. During 1967-72, the most serious problem on the Columbia River was supersaturation of atmospheric gases (toxic to most fish) induced by turbulence at spillways. Radioactivity levels originate at AEC Hanford Works. Temperature levels reach or exceed desired levels in the summer months. Nutrient levels (phosphorus and nitrate) exceed desirable thresholds primarily during the first spring flood.

- *Harmful Substances.* Supersaturation of dissolved gases induced by turbulence by spillways present toxic conditions below 13 dams along the river. The toxicity resulting in gas bubbles in the bloodstream is similar to the "bends" experienced by divers. The problem is not limited to any particular species or age groups of fish. Specific radionuclides that concentrate in the food chain (zinc-65 and phosphorus 32) continue to be detected at the mouth of the Columbia River and in oysters taken on the Washington Coast.
- *Physical Modification.* The general physical quality of the Columbia is good, but temperatures reach or exceed the established upper limit in August and occasionally in July and September. Temperature levels are influenced by the many dams and reservoirs, and also by heat sources such as the Hanford Works. Temperature levels have shown no observable overall change during the past 6 years. Other water quality measurements such as solids pose no problem.
- *Eutrophication Potential.* With the exception of slime growth, sphaerotilus natans,

in the lower river, the biological populations of the river are diverse and balanced—the opposite of eutrophic conditions. Although nitrate and phosphorus exceed desirable levels, particularly during high runoff periods, there are no trends suggesting increased eutrophication.

- *Oxygen Depletion.* The flow and surface characteristics of the river seem to be sufficient to provide dissolved oxygen concentrations that are very close to theoretical saturation limits.
- *Health Hazards and Aesthetic Degradation.* From limited data, total and fecal coliforms levels are very low and indicate no threat to water contact and drinking water uses.

NONPOINT SOURCES

In addition to studying overall levels and trends, the EPA report analyzed pollution that comes, not from specific points such as sewage treatment outfalls or industrial plants, but from runoff from areas such as farmlands, city streets, and mining areas, and from subsurface seepage from polluted areas. While reliable national estimates exist for point-source pollution, no similar estimates exist for nonpoint-source pollution. In 1971, EPA estimated that agriculture, mining, and water resource development accounted for 31 percent of the total pollution measured. This estimate is not particularly useful, however, because it did not delineate the kinds of pollutants involved, the quantity of nonpoint source pollutants compared to point source pollutants, and the percent of time that nonpoint sources are active (usually only during rainy periods).

III. Municipal Costs

THE STATUS OF PUBLIC SEWERAGE

The Nation's system of public sewerage facilities has been growing for more than a century. The first U.S. sanitary sewer was begun in Chicago in 1855, only 12 years after the world's first sanitary sewer system was installed in Hamburg, Germany. By the end of that decade an estimated 1 million persons were being served by U.S. sewers (Table III-1). The growth of sewerage services occurred at a rate well in excess of the rate of population growth, and by 1932 approximately half of the Nation's population was served by sanitary sewers. Today the sewered population is somewhat in excess of our total urban population.

While the technology of sewerage treatment was developed in England during the 1840's and 1850's, it was not until the 1870's that collecting sewers in the United States began to be complemented by an occasional sewerage treatment plants. The number of persons being served by treatment plants apparently reached 1 million in 1904, at a time when the sewered population was approximately 28 million. A great number of sewage treatment plants must have been installed between 1910 and 1932, for in 1932 the number of persons served by sewage treatment was about five times the number served in 1910. By 1940, under the stimulus of "New Deal" construction programs, the population

TABLE III-1

EXPANSION OF PUBLIC SEWERAGE SERVICES

Year	U.S. population	Unsewered population	Sewered population	Sewage untreated	Sewage treated	Relationships	
						Sewered population / Total population	Treated population / Sewered population
			(millions of persons)			(expressed as percent)	
1860	31	30	1	1	0	3%	0%
1870	39	34	5	5	0	13	0
1880	50	40	10	n.a.	n.a.	20	n.a.
1890	63	47	16	n.a.	n.a.	25	n.a.
1900	76	51	25	n.a.	n.a.	33	n.a.
1904	82	54	28	27	1	34	4
1910	92	57	35	31	4	38	11
1915	99	57	42	n.a.	n.a.	42	n.a.
1920	106	58	48	n.a.	n.a.	45	n.a.
1930	123	62	61	n.a.	n.a.	50	n.a.
1932	125	63	62	41	21	50	34
1940	133	66	67	30	37	50	55
1945	140	70	70	28	42	50	60
1948	145	72	73	28	45	50	62
1957	171	73	98	24	74	57	76
1962	186	68	118	17	101	73	86
1968	198	58	140	11	129	71	92
1973	210	47	163	4	159	76	97

Source: Based on data published by EPA (and predecessor agencies) in the Municipal Waste Inventories.

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served by treatment facilities was almost double that of 1932, and by about 1957 it doubled again to 74 million. By 1973 approximately 159 million persons were being served, or more than 97 percent of the total sewered population.

Improvements in Waste Treatment. The treatment of liquid wastes may involve complex chemical and biological processes. Enormous volumes of water must be handled—30 to 600 gallons per capita per day, depending on the industrial and commercial development in a community. These volumes must be handled under circumstances of radical daily flow variation. Furthermore, the materials to be removed are present in minute quantities: The "normal" concentration of BOD_5 and of suspended solids in sewage is about 200 milligram per liter, or 0.0002 pounds per pound of water.

Given such difficulties, waste treatment technology developed early in directions that featured the acceleration of natural processes in very long-lived reactors that could function under a range of operating conditions. These basic principles have remained largely unchanged, although designs have been improved and there has been a progressive increase in the application of mechanical energy and chemical processes to supplement and accelerate natural processes.

Our historical knowledge of improvements and efficiencies of waste treatment methods is incomplete in that no data on the national distribution of waste treatment processes were gathered prior to *Engineering News Record*'s 1937 survey of municipalities. Since that time, the Federal Government has issued intermittent *Municipal Waste Inventories*, which provide data on the distribution of waste treatment methods and their removal efficiency.

A review of these sources indicates that the population discharging untreated wastes into our waterways is only one-tenth of what it was in 1937 (Table III-2). During the 1937-73 period, the number of persons whose wastes receive primary treatment (physical processes that remove roughly 90 percent of solids and about 35 percent of BOD_5) has almost tripled. The population employing secondary treatment (biological processes that produce only a slight incremental reduction in solids concentrations but raise removal of BOD_5 to the 70 to 95

TABLE III-2

DEGREE OF SEWAGE TREATMENT

Year	No treatment	Primary treatment	Intermediate treatment	Secondary treatment	Tertiary treatment
	(millions of persons served by sanitary sewerage facilities)				
1937	35.8	16.7	2.8	16.3	—
1940	29.9	15.1	3.3	18.9	—
1945	27.9	17.2	3.8	21.7	—
1948	28.0	18.4	3.6	22.7	—
1957	23.8	25.7	5.6	43.3	—
1962	17.0	32.7	7.4	61.2	—
1968	10.9	36.9	5.9	85.6	0.3
1973	3.9	46.3	5.9	103.9	2.8
Annual rate of change, 1937-1973	-8%	+4%	+3%	+7%	—

Sources: 1937, *Engineering News Record*'s survey of municipalities 1940-73, EPA and predecessor agencies in *Municipal Waste Inventories*.

TABLE III-3

EFFECT OF SANITARY SEWAGE TREATMENT

Year	Collected by sanitary sewers*	Reduced by treatment**	Discharged by treatment plants
	(millions of pounds of BOD_5 per day)		
1957	16.4	7.7	8.7
1962	19.8	10.8	9.0
1968	23.3	15.0	8.3
1973	27.1	18.5	8.6

*Based on 0.167 pounds of BOD_5 per sewered person per day.

**Based on the distribution of treatment facilities shown in Table III-2 and on estimates of removal efficiency from a variety of sources.

percent level) increased more than sixfold and now includes about 63 percent of the sewered population.

Not only have more persons been connected to more advanced types of sewerage treatment facilities, but technological modifications have improved the removal efficiencies of each type. One result is that the amount of BOD_5 removed by treatment facilities in 1973 exceeded the total BOD_5 produced by sanitary sewers in 1957 (Table III-3).

The end result of the growth in sewerage facilities appears to be disappointingly marginal, however. While one portion of the system, the treatment facilities, increased by 140 percent the amount of BOD_5 diverted from our waterways, another portion, sanitary sewers, offset that improvement by delivering more BOD_5 for treatment. These figures may be overly pessimistic as they pertain to sanitary sewerage only; they do not reflect the net result of initiating public treatment for a large (but unknown) number of industrial facilities that previously discharged directly into our waterways. On the other hand, they do not take into account the increased concentration of wastes in sanitary sewerage resulting from such innovations as kitchen garbage disposals.

Investment in Treatment Facilities. Between 1855 and 1971, the Nation invested an estimated $58 billion (1972 dollars) in its public sewerage facilities (Table III-4). This represents about 5 percent of total State and local government capital expenditures for *all* purposes since 1915 and resulted in approximately $32 billion worth of facilities in place as of 1971.

Two aspects of this series of investments stand out. First, the bulk of sewerage capital has been installed very recently—almost 80 percent since 1929, 60 percent since World War II, and more than 30 percent since 1961. Second, the stock of capital in place is so large compared to annual investments that replacement of existing facilities has absorbed approximately 50 percent of all capital expenditures since 1961. The current level of replacement costs is close to $1 billion a year and rising in proportion to the growth of the capital stock.

THE NEEDS SURVEY

The estimated cost of constructing needed public sewerage facilities is $60.1 billion, according to a survey EPA conducted in mid-1973.[1] The "Needs" Survey, which was required by Section 516(b)(2) of the 1972 Amendments, covered only those treatment and collection facilities that are eligible for Federal assistance and meet the criteria of the survey. Nevertheless,

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[1] *Costs of Construction of Publicly Owned Wastewater Treatment Works—1973 Needs Survey*, EPA report to Congress, November 1973.

TABLE III-4

INVESTMENT IN PUBLIC SEWERAGE FACILITIES

Period	Gross investment*	Replacement†	Net investment	End-of-period capitalization
		(billions of 1972 dollars)		
1856-69	$ 0.5	$ 0.1	$ 0.4	$ 0.4
1870-79	0.6	0.1	0.5	0.9
1880-89	0.8	0.2	0.6	1.5
1890-99	1.2	0.4	0.8	2.3
1900-09	1.5	0.6	0.9	3.2
1910-19	2.7	0.9	1.8	5.0
1920-29	5.7	1.6	4.1	9.1
1930-34	2.5	1.3	1.2	10.3
1935-39	4.8	1.6	3.2	13.5
1940-45	2.1	2.3	(.2)	13.3
1946-56	10.8	5.1	5.7	19.0
1957-61	7.5	3.2	4.3	23.3
1962-67	9.1	4.8	4.3	27.6
1968-71	8.6	3.9	4.7	32.3
Totals	$58.4	$26.1	$32.3	

*Based on data published by the Department of Commerce and by EPA; all values converted to 1972 dollars through use of EPA's sewerage construction cost indices and the discontinued Associated General Contractor's Index of Construction Costs.

†Estimated funds required to "replace" existing facilities, rather than add new capacity. Computed at a rate of 2 percent for sewers and 4 percent for plants, based on estimates of the relative weight of each in each period.

these costs are approximately equal to the Nation's total investment in public sewerage facilities since the first sanitary sewer was built in 1855.

Conduct of the Survey. In mid-1973, the States were asked to distribute survey questionnaires to all municipal treatment authorities that could be identified within Standard Metropolitan Statistical Areas (SMSA's), and also to all authorities outside SMSA's serving communities of 10,000 or more. Thirty-five States chose to sample communities of less than 10,000 outside SMSA's, in which case the costs reported in the sample were increased in proportion to the sample coverage. The remaining 15 States surveyed all communities. Municipal treatment authorities sent their completed questionnaires to the States for review and approval. After further review and editing by EPA Regional Offices, the survey data were compiled by State and for the Nation as a whole.

Costs were reported for facilities in five categories, as follows:

- *Category I—Secondary Treatment Required by 1972 Act.* This category includes costs for facilities that would provide a legally required level of "secondary" treatment. As a minimum under the 1972 Amendments, all municipal treatment facilities are required to reduce BOD_5, suspended solids, and fecal coliforms by July 1, 1977 to at least the level established by EPA in its definition of "secondary" treatment. This level of treatment meets or exceeds the requirements of water quality standards for many waterways. Facilities along some waterways are required, however, to reduce these types of pollutants still further to meet water quality standards. The costs for this additional "secondary" treatment are also included in Category I.

- *Category II—Treatment "More Stringent" than Secondary Required by Water Quality Standards.* This category includes costs for facilities that would remove pollutants such as phosphorus, ammonia, nitrate, and organic substances to the extent required by legally binding Federal, State, or local actions. Such actions include an EPA-approved water quality plan, an administrative or court order, a license, and water quality standards that are binding on the treatment facility. These costs are in addition to those for secondary treatment reported in Category I.
- *Category III—Rehabilitation of Sewers to Correct Infiltration and Inflow.* Costs could be reported in this category for a preliminary analysis to determine if excessive infiltration and inflow exist. If such an analysis had been completed by the time of the survey and showed that infiltration/inflow did exist, the expense of a detailed evaluation of the cost of rehabilitation of the sewer system could be reported. If such an evaluation was already completed at the time of the survey, the costs of facilities could be reported.
- *Category IV—New Sewers.* This category consists of the costs of new collector and interceptor sewers designed to correct violations caused by raw discharges, seepage to waters from septic tanks, and the like, or to comply with legally binding Federal, State, or local actions. As provided in the 1972 Amendments, costs could be reported only if the community had sufficient existing or planned capacity to treat adequately the collected sewage, and only for communities existing prior to enactment of the 1972 Amendments. (Collectors for new communities, new subdivisions, and newly developed urban areas are excluded.)
- *Category V—Correction of Overflows from Combined Sewers.* Costs could be reported, when required by legally binding Federal, State, or local action, for correcting periodic bypassing of untreated wastes from combined sanitary and storm sewers. The alternative methods for correction must have been evaluated, however, and the reported costs based on the most economical or efficient alternative.

The costs for facilities reported in each category were subject to three overall constraints:

- Costs are in June 1973 dollars.
- Costs are estimated for facilities designed to serve no more than the 1990 population projected for each State by the Bureau of the Census in its "series E" projection published in December 1972.
- Only those costs and facilities that could be clearly defined and documented are reported. As a result, some types of facilities eligible for Federal assistance under the 1972 Amendments are excluded—primarily treatment facilities that would achieve "best practicable treatment technology" and the 1985 goal of "zero discharge," and facilities for prevention, control, and treatment of pollution from storm waters that do not flow through combined sewers.

Survey Results. The costs reported in the survey and meeting EPA review criteria totaled $60.1 billion (Table III-5), broken down as follows:

	Billions of 1973 dollars
Category I	$16.6
Category II	5.6
Category III	.7
Category IV	24.4
Category V	12.7
Total	$60.1

As shown in Table III-6, the costs reported amount to $286 per capita on a nationwide basis.

For a number of reasons, the reported costs are considered to underestimate the actual expenditures necessary to provide even the kinds of facilities that meet the survey guidelines. The major factors involved are:

- Costs reported in Category I and II do not reflect the additional treatment that will have to be provided in response to the revisions in water quality standards now underway in many States.
- Costs reported in Category V reflect only a fraction of the total expenditures that

TABLE III-5

ESTIMATED CONSTRUCTION COSTS FOR NEW PUBLIC TREATMENT FACILITIES (FROM NEEDS SURVEY)*

(millions of 1973 dollars)

	Total costs	I—Improvement of treatment plants to achieve secondary level	II—Improvement of treatment plants to achieve more stringent treatment levels	III—Correction of infiltration /inflow conditions	IVa—Eligible new interceptors force mains, pumping stations	IVb—Eligible new collectors	V—Reduction of combined sewer overflows
Region I							
Connecticut	$ 1,409	$ 179	$ 46	$ 18	$ 205	$ 225	$ 736
Maine	364	124	1	1	135	87	16
Massachusetts	1,485	459	51	11	251	77	636
New Hampshire	508	174	13	2	152	102	65
Rhode Island	367	61	7	1	94	169	35
Vermont	168	65	16	1	34	32	20
Region II							
New Jersey	3,382	1,458	321	18	851	532	202
New York	8,032	1,556	731	11	1,878	876	2,980
Puerto Rico	590	169	—	2	225	194	—
Virgin Islands	44	13	—	—	19	12	—
Region III							
Delaware	329	84	7	4	110	62	62
Maryland	681	217	139	2	227	95	1
Virginia	1,345	516	137	12	345	208	127
West Virginia	614	96	3	14	224	268	9
Pennsylvania	4,210	884	133	40	538	1,026	1,589
District of Columbia	1,081	2	48	1	2	1	1,027
Region IV							
Alabama	444	130	19	4	161	130	—
Florida	2,371	747	144	32	699	746	3
Georgia	1,031	338	136	7	303	200	47
Kentucky	1,032	165	84	9	324	293	157
Mississippi	268	88	60	5	75	40	—
North Carolina	900	353	152	3	244	148	—
South Carolina	757	326	6	5	237	183	—
Tennessee	695	234	10	5	223	211	12
Region V							
Illinois	4,089	1,009	805	41	353	422	1,459
Indiana	1,040	243	107	3	192	91	404
Michigan	3,325	525	115	14	820	992	859
Minnesota	1,065	310	41	9	187	163	355
Ohio	2,833	691	482	342	668	409	241
Wisconsin	787	212	45	13	229	121	167
Region VI							
Arkansas	355	97	1	—	126	130	1
Louisiana	451	94	—	3	157	197	—
New Mexico	115	54	—	—	12	49	—
Texas	889	297	4	7	355	225	—
Oklahoma	624	208	21	2	256	137	—
Region VII							
Iowa	502	236	44	7	141	50	24
Kansas	671	141	24	2	167	316	21
Missouri	972	442	9	3	329	189	—
Nebraska	404	121	—	3	20	25	235
Region VIII							
Colorado	426	175	20	20	115	74	22
Montana	74	34	—	1	25	13	1
North Dakota	46	17	—	—	13	8	8
South Dakota	43	31	3	1	6	2	—
Utah	225	148	—	1	22	53	1
Wyoming	40	20	—	—	10	10	—

TABLE III-5 (Continued)

	Total costs	I—Improvement of treatment plants to achieve secondary level	II—Improvement of treatment plants to achieve more stringent treatment levels	III—Correction of infiltration /inflow conditions	IVa—Eligible new interceptors force mains, pumping stations	IVb—Eligible new collectors	V—Reduction of combined sewer overflows
				(millions of 1973 dollars)			
Region IX							
Arizona	237	76	3	—	73	86	—
California	6,050	2,190	1,531	6	1,022	527	774
Hawaii	523	222	4	—	213	84	—
Nevada	227	39	119	—	47	22	—
American Samoa	8	4	—	—	3	1	—
Guam	22	17	—	—	3	2	—
Trust Territories	8	4	—	—	2	2	—
Wake Island	—	—	—	—	—	—	—
Region X							
Alaska	205	80	—	—	73	44	8
Idaho	112	40	3	1	33	35	—
Oregon	568	140	—	2	146	130	150
Washington	1,080	284	5	2	247	299	243
Total	$60,123	$16,639	$5,650	$691	$13,621	$10,825	$12,697

*Costs ineligible under the survey guidelines are excluded. Costs are affected by limitations of survey design, inconsistency in reporting, variations in planning status among States, and other variables explained in the report. Therefore, the costs should not be considered indicative of equitable shares for individual States or of total funds required to meet "needs" without careful review of the report's limitations.

> could have been justified under the survey guidelines if more localities had completed the required studies. By crudely extrapolating the results of the few studies available, EPA estimates that facilities required to reduce the major pollution concentrations in combined sewer overflows by 50 to 85 percent would cost from $40 to $80 billion, rather than the $12.7 billion indicated by the survey.

It is possible that, had all the required studies been completed, the total costs in all five categories would have been roughly double the amount actually reported.

Comparisons to Previous Surveys. Local estimates of the cost of needed municipal treatment facilities have been consolidated into overall national totals almost every year since 1959. The Conference of State Sanitary Engineers made estimates from 1959 to 1966 in its annual report. The Federal Water Pollution Control Administration and EPA have made annual estimates since 1969. The Federal estimates are based on information about existing facilities and pending needs, much of it assembled by State water pollution control agencies. EPA supplemented this information in 1970 and in 1971 with surveys of cities with the largest anticipated needs. These various estimates show an incessant growth in estimated "needs" (Table III-7). Unfortunately, it is difficult to compare these individual estimates, for several reasons:

- Most surveys have focused on only those projects eligible for Federal financial assistance. The 1972 Amendments expanded the categories of eligible projects to include collection sewers, infiltration/inflow, and separation of combined sewers. In addition, previous surveys focused on the "backlog of unmet needs," while the costs included in the 1973 survey presumably provide for future growth in service and replacement of existing facilities as well.
- The characteristics of water quality to be measured and the level of treatment intensity to be attained have continued to increase.
- Inflation—as measured by the EPA indices of sewerage construction costs—has continued, amounting to 22 percent between 1970 and 1972, and averaging approximately 8 percent a year between 1967 and 1972.
- As more Federal funds have become available, local officials have been encouraged

TABLE III-6

PER CAPITA COSTS FOR CONSTRUCTION OF NEW PUBLIC TREATMENT FACILITIES (FROM NEEDS SURVEY)*

	Total costs (millions of 1973 dollars)	1972		1990	
		Population (000's)	Costs per capita	Projected population (000's)	Costs per capita
Region I					
Connecticut	$ 1,409	3,082	$457	3,946	$357
Maine	364	1,029	354	1,142	319
Massachusetts	1,485	5,787	257	7,052	211
New Hampshire	508	771	659	907	560
Rhode Island	367	968	379	1,134	324
Vermont	168	462	364	536	313
Region II					
New Jersey	3,382	7,367	459	8,822	383
New York	8,032	18,366	437	21,799	368
Puerto Rico	590	—	—	—	—
Virgin Islands	44	—	—	—	—
Region III					
Delaware	329	565	582	732	449
Maryland	681	4,056	168	5,001	136
Virginia	1,345	4,764	282	5,958	226
West Virginia	614	1,781	345	1,811	339
Pennsylvania	4,210	11,926	353	13,332	316
District of Columbia	1,081	748	1,445	764	1,415
Region IV					
Alabama	444	3,510	126	3,850	115
Florida	2,371	7,259	327	9,159	259
Georgia	1,031	4,720	218	5,667	182
Kentucky	1,032	3,299	313	3,741	276
Mississippi	268	2,263	118	2,359	114
North Carolina	900	5,214	173	5,880	153
South Carolina	757	2,665	284	3,023	250
Tennessee	695	4,031	172	4,800	145
Region V					
Illinois	4,089	11,251	363	13,177	310
Indiana	1,040	5,291	197	6,433	162
Michigan	3,325	9,082	366	10,961	303
Minnesota	1,065	3,896	273	4,577	233
Ohio	2,833	10,783	263	13,202	215
Wisconsin	787	4,520	174	5,218	151

TABLE III-6 (Continued)

	Total costs (millions of 1973 dollars)	1972		1990	
		Population (000's)	Costs per capita	Projected population (000's)	Costs per capita
Region VI					
Arkansas	355	1,978	179	2,068	172
Louisiana	451	3,720	121	4,159	108
New Mexico	115	1,063	108	1,232	93
Texas	889	11,649	76	13,666	65
Oklahoma	624	2,634	236	2,942	212
Region VII					
Iowa	502	2,883	174	3,053	164
Kansas	671	2,258	297	2,509	267
Missouri	972	4,753	205	5,488	177
Nebraska	404	1,525	265	1,562	257
Region VIII					
Colorado	426	2,357	181	2,848	150
Montana	74	719	103	714	104
North Dakota	46	632	73	606	76
South Dakota	43	679	63	643	67
Utah	225	1,126	200	1,293	174
Wyoming	40	345	116	348	115
Region IX					
Arizona	237	1,945	122	2,500	95
California	6,050	20,468	296	26,601	227
Hawaii	523	809	646	962	544
Nevada	227	527	431	829	274
American Samoa	8	—	—	—	—
Guam	22	—	—	—	—
Trust Territories	8	—	—	—	—
Wake Island	0	—	—	—	—
Region X					
Alaska	205	325	631	408	502
Idaho	112	756	148	758	148
Oregon	568	2,182	260	2,493	228
Washington	1,080	3,443	314	4,194	258
Total	$60,123	208,232	$286	246,859	$241†

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*Costs ineligible under the survey guidelines are excluded. Costs are affected by limitations of survey design, inconsistency in reporting, variations in planning status among States, and other variables explained in the report. Therefore, the costs should not be considered indicative of equitable shares for individual States or of total funds required to meet "needs" without careful review of report's limitations.

†Excluding Puerto Rico and Territories.

TABLE III-7

ESTIMATES OF CONSTRUCTION REQUIREMENTS FOR NEW PUBLIC TREATMENT FACILITIES, 1962-1971

Source	Year	Estimate (billions of dollars)
Conference of State Sanitary Engineers	1962	$ 2.0
Conference of State Sanitary Engineers	1966	2.6
Federal Water Pollution Control Administration	1969	10.0
Environmental Protection Agency	1970	12.6
Environmental Protection Agency	1971	18.1

to refine and update their estimates. The 1973 survey, in particular, was intended to serve as the sole basis for allocating Federal funds among the States.

- The 1973 survey covered far more localities than did the previous estimates. Also, more engineering studies, which have generally proven higher than rule-of-thumb estimates, were available as a basis for detailed cost estimates.
- EPA's 1970 survey covered a 43-month future investment period, the 1971 survey a 60-month period. The 1973 survey did not specify a period, but localities are faced with the requirement of meeting effluent limitations based on secondary treatment by mid-1977, thereby accelerating desired construction schedules.

Validity of the Survey Approach. The primary advantage of surveys such as the ones discussed is that they can provide a means for acquiring cost data from the local level, where specific costs can best be identified and calculated. However, there are a number of limitations to this approach, in addition to the lack of comparability. A recent study pointed out that individual estimates of needs may be based upon varying rules-of-thumb or upon engineering studies, and that costs may be expressed in current or constant dollars.[2] Surveys may reflect the summation of individual estimates of *desired* construction activity, rather than the activities that are actually anticipated to occur. For reasons such as these, EPA has generally constructed alternative cost estimates based upon overall statistical functions for unit costs, growth, and capital replacement. Such alternative cost estimates are currently under development.

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[2] Frumkin, Norman. *Capital Investment for Water Pollution Control at the State and Local Level.* EPA contract no. 68-01-0164. August 1972.

IV. Industrial Costs

The emphasis of this chapter is on the costs industry will incur in meeting 1977 effluent standards set by the 1972 Amendments. The Amendments require industries to use "best practicable" water pollution control technology by mid-1977 and the "best available" by mid-1983.

The examination of industrial costs is divided into two parts. The first is a very broad analysis and discussion of the costs associated with meeting the 1977 standards, excluding those related to utility steam-electric generating plants. The costs are developed for 15 industrial groupings that encompass virtually all industrial water-polluting activity. The second section examines the costs and impacts associated with utility steam-electric generating plants. This control problem is discussed separately, primarily because of its distinct nature.

NONTHERMAL COSTS

While municipal sources are generally the largest contributors of water pollutants, industrial wastes frequently present the most difficult control problems. Municipal wastewater does not, as a rule, vary greatly in pollutant content and concentration. In contrast, content and concentration vary widely in the industrial sector, depending on the type of industry and the specific manufacturing process used. The wide variations present problems of data collection and analysis, making a definitive assessment of costs virtually impossible at this time. The results, therefore, should be viewed only as improvements over earlier assessments of industrial pollution costs.

SCOPE

The cost estimates presented are based upon best practicable technology, which industry must be using by 1977. Estimates based on best available technology and zero discharge were not made for this report. In certain cases, however, best practicable technology will require zero discharge.

Estimates are developed for a total of 15 major industrial groups defined by Standard Industrial Classifications (SIC) (Table IV-1). Animal feedlot operations, while not involving manufacturing, are included because their discharges may be controlled on a point-source basis.

While a number of alternatives are available to industries to control wastewater, the report assumes that industries will treat the wastes it produces on-site. Other alternatives, such as increased recycling and modification of the manufacturing process to use less water, would probably not be as costly as on-site treatment. Joint industrial-municipal treatment is another alternative. However, data are not available to cost out these options.

The type of cost information developed on the 15 industries includes: the dollar value of capital investment in water pollution control facilities currently in place, the additional capital investment required, and the distribution of these investments by industries, States, and regions.

STUDY DESIGN

In developing the industrial cost model, the following ground rules were established for data collection and use:

- The most recent data on water use, industrial plants, and costs of control alternatives were to be used.
- Existing data would be used, rather than developing independent data.
- Compatibility would be maintained where possible with the data developed for prior reports on the economics of clean water.

TABLE IV-1

INDUSTRIES FOR WHICH WATER POLLUTION CONTROL COSTS ARE ESTIMATED

SIC code no.	Definition
02	Animal feedlots
20	Food and kindred products
22	Textile mill products
24	Lumber and wood products
26	Paper and allied products
28	Chemicals and allied products
29	Petroleum refining and related industries
30	Rubber and miscellaneous plastics products
31	Leather and leather products
32	Stone, clay, glass, and concrete products
33	Primary metals
34	Fabricated metals products
35	Nonelectrical machinery
36	Electrical and electronic machinery
37	Transportation equipment

The actual industrial cost model was developed in the 1972 *Economics of Clean Water.*[1] It is best summarized by an informational flow chart (Figure IV-1):

- Aggregate data from *Water Use in Manufacturing* were converted to indicate total water use for each manufacturing employee by SIC code and 17 water use regions.[2] For this analysis, the following regions are combined: Cumberland and Tennessee, Alaska and Pacific Northwest, and Hawaii and California. Six water use scenarios were developed based upon different assumptions about water use efficiencies (Table IV-2). The 1968 data indicate a large difference in industrial water use per employee based on geographical location. Additionally, the geographic areas with low water use per employee were areas with little available water or with low quality water. This use pattern indicates either that different specific processes are used in different areas or that water is used more economically in certain areas. Since economizing on water is an alternative to treatment and may be less costly, this report identifies and simulates a series of possible water-use scenarios that might more realistically represent water use today than the 1968 water-use data.
- Model computations were made to determine the total annual water use for each manufacturing sector listed in an extract of the Dun's Market Identifiers (DMI) file of nearly 250,000 plants.[3] Totals were computed taking into consideration employment, SIC, and water-use region. A plant was eliminated from further consideration if its annual water use was less than 1 million gallons. For plants using more, capital and operation and maintenance (O&M) costs were computed for each of the required treatment types. The costs, along with descriptive data, were saved for use in the various summaries.
- Cost data were converted to equations that relate the daily water use or flow requiring treatment to each of the 12 treatment

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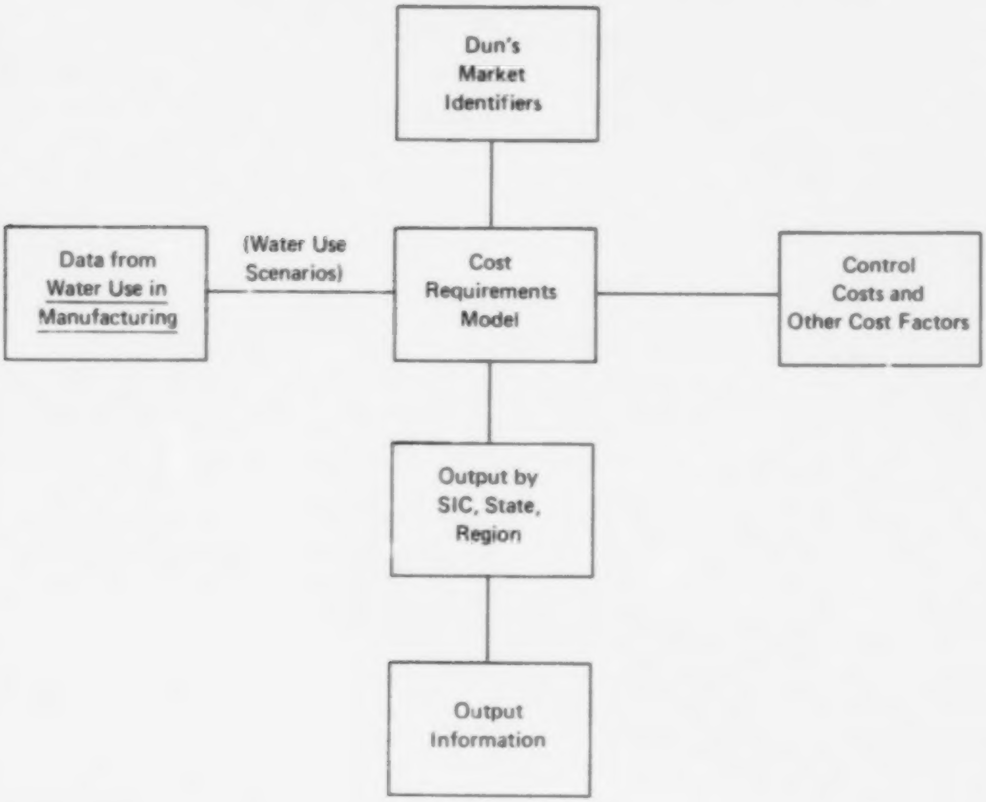
[1] *Economics of Clean Water, 1972.* EPA. Vol. 2.

[2] *1967 Census of Manufactures: Water Use in Manufacturing.* Bureau of the Census. Report No. MC67(1)-7. 1971. Data are for 1968.

[3] Dun's Market Identifiers (DMI), Computer file maintained by Dun & Bradstreet, Inc., and available to EPA under contract (extract of June 1973 file used).

FIGURE IV-1

COMPUTATION OF INDUSTRIAL COSTS OF WATER POLLUTION CONTROL


Dun's Market Identifiers
Data from Water Use in Manufacturing
(Water Use Scenarios)
Cost Requirements Model
Control Costs and Other Cost Factors
Output by SIC, State, Region
Output Information

types listed in Table IV-3. For each SIC, one or more of the treatment processes was assumed to be required for a certain percentage of plant flow.

- An output program was developed that aggregated the individual plant data by SIC (2-, 3-, or 4-digit), EPA Region, State, and water-use region. Summaries of this information constituted the outputs of the modelling process.

COMPARISON WITH THE 1972 REPORT

The methods used to compute the industrial costs of water pollution control were modified somewhat from those used in the 1972 report. The most significant modifications were made in the computational procedures and the input data files:

- *Efficiency of water use scenarios.* Water Use Scenario 3, (the eight least efficient regions move closer to the median regional efficiency in 1968) was added. It appears the most likely scenario for 1972-77 because it represents a realistic adjustment in water use by older plants.
- *Dun's Market Identifier.* The most recent (1973) DMI file was used, and the method of plant selection was changed from the 1972 analysis. In the 1972 report, the largest 14,499 plants were selected from the file on the basis of employment. This subset, generally corresponding to water use greater than 10 million gallons per year, was then used for all scenarios. In this

TABLE IV-2

WATER USE SCENARIOS

Scenario number	Description	1972 Report	1973 Report
1	Water-use efficiencies not changed from 1968 efficiencies.*	Used	Used
2	Efficiency of the least efficient water-use region increased to that of the next to the least efficient.	Used	Used
3†	Efficiencies of the eight least efficient regions (nearly half of the regions) increased to half way between their 1968 efficiency and the median regional efficiency in 1968.	Not used	Used
4	Efficiencies of the eight least efficient regions increased to the efficiency of the 1968 median region.	Used	Used
5	Efficiencies of the 10 least efficient regions increased to the efficiency of the least efficient of the remaining regions.	Used	Used
6	Efficiencies of all 17 regions increased to that of the most efficient region in 1968.	Used	Used

*Efficiencies pertain to water use per employee within an industrial classification.

†Considered in this report to be the most likely to occur.

year's assessment, water use was calculated for all plants, and those plants that used water in excess of 1 million gallons per year were retained. This produced a total of 148,074 plants for Scenario 1. Somewhat fewer plants were modeled for the other five scenarios, since fewer plants passed the 1 million gallons per year criterion. (A use of 1 million gallons per year corresponds to the average annual use of only 30 people. Plants using less than this amount are most likely using municipal treatment facilities, or applying their discharges to land.) Table IV-4 compares the number of plants included in the two reports and the corresponding water used.

- *Cost curves.* The cost curves were prepared especially for this study by Associated Water and Air Resource Engineers, Inc.[4] The costs were adjusted to 1972 dollars. The cost curves in the 1972 reports were distilled from industrial wastewater guidelines prepared for EPA and its predecessor agencies.
- *Industry coverage.* Animal feedlots, SIC 02, were included in this series of reports for the first time.

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[4] *Analysis of National Industrial Water Pollution Control Costs.* Associated Water and Air Resource Engineers, Inc., Nashville, Tenn. EPA Contract No. 67-01-1536. May 1973.

TABLE IV-3

TYPES OF WATER TREATMENT MODELED

Treatment code	Treatment process
1	Oil separation
2	Equalization
3	Coagulation
4	Neutralization
5	Air flotation
6	Sedimentation
7	Aeration
8	Natural stabilization
9	Chlorination
10	Evaporation
11	Incineration
12	Activated sludge

TABLE IV-4

NUMBER OF PLANTS AND WATER USE IN 1972 AND 1973 REPORTS ON ECONOMICS OF CLEAN WATER*

SIC code no.	Industry	Number of plants		Water use (mgy)†	
		1972 report	1973 report	1972 report	1973 report
20	Food and kindred products	4,494	23,034	743,829	973,741
22	Textile mill products	1,021	7,439	193,383	323,727
24	Lumber and wood products	405	18,439	89,627	408,493
26	Paper and allied products	862	5,451	2,111,424	3,059,948
28	Chemicals and allied products	1,421	12,426	1,235,840	2,125,533
29	Petroleum refining and related industries	334	1,825	313,161	337,377
30	Rubber and miscellaneous plastics products	459	6,234	48,037	90,481
31	Leather and leather products	215	3,345	51,027	127,090
32	Stone, clay, glass, and concrete products	945	14,865	190,163	619,374
33	Primary metals	1,137	6,251	1,358,716	1,251,163
34	Fabricated metal products	1,037	17,487	79,555	213,376
35	Nonelectrical machinery	790	14,479	70,995	146,502
36	Electrical and electronic machinery	817	8,304	109,859	161,153
37	Transportation equipment	562	4,976	82,337	169,379
	Total	14,499	144,555	6,677,953	10,007,337

*Excluding feedlots.

†Million gallons per year.

- *Costs incurred by new plants.* The costs incurred by new plants were based on national projected growth rates for each industry. The rates were obtained from the National Planning Association's National Economic Projections Series.[5] The 1972 report assumed that all industries expanded at 7.8 percent over the period 1972-1977.

SUMMARY OF INDUSTRIES

The final cost figures are presented in terms of broad industry groups. In many cases, however, the treatment procedure within a group had to be modified to accommodate internal industry variations. Not only were the water use ratios varied, but the actual treatment process had to be changed for different types of plants within the same basic industry.

Animal Feedlots, SIC 02. The primary reason for including animal feedlots is the specific language of the 1972 Amendments, which require feedlots—along with the more conventional categories of industry—to conform to effluent standards and to be subject to waste discharge permits.

A feedlot can generally be defined as a high concentration of animals held in a small area for extended periods of time for agricultural production purposes and fed specially transported foods. The following are the major subcategories requiring effluent controls:

SIC Code	Subcategories
0211	Beef cattle
0213	Hogs
0214	Sheep
0241	Dairy farms
0251, 0252	Chickens and eggs
0253	Turkeys
0259	Ducks
0272	Horses

Of these eight categories, beef cattle, hogs, and dairy farms were selected for detailed analysis. Chickens, turkeys, sheep, and horses were not studied in detail because their current production does not present as great a pollution potential. Data were not available to support analysis of duck feedlots.

The results of the analysis are shown in Table IV-5. The values were derived from data covering lots of various capacities. The incidence of rain was used in the analysis rather than water use, since the pollution controlled is runoff as opposed to process water. Thus, the methodology for cost calculation is different from that previously described and applied to the other industries.

Food and Kindred Products, SIC 20. While wastes from food industries generally require biological treatment, differences in raw waste BOD_5 concentrations and other treatment requirements specific to each segment of the industry required that several of the segments be separately analyzed.

Textile Mill Products, SIC 22. Segments of the textile industry engaged in dyeing and finishing of textile products were analyzed together. Separate designs were made for cotton and synthetics plants, and for wood processing. Plants engaged in scouring and topping of wool were not included primarily because of data deficiencies.

Lumber and Wood Products, SIC 24. The major categories in the industry are involved in the manufacture of assorted wood products such as plywood and flooring. One treatment configuration was used based on representative requirements.

Paper and Allied Products, SIC 26. Several different designs were necessary for adequate treatment of the paper industry. Because water use information was available for only the entire category of pulp mills, a single waste treatment sequence was developed based on average raw waste characteristics. In addition, because pulp mills are frequently integrated into complexes manufacturing both pulp and paper, one design was done for these two segments of the industry. Additional designs were included for paperboard mills and for building board mills.

Chemicals and Allied Products, SIC 28. Because of the industry's great diversity, no standard treatment procedure could be assigned to all 4-digit SIC codes involved in the chemical industry. The industry was divided into 15 subclasses that encompass the major sections of the industry.

Petroleum Refining and Related Industries, SIC 29. The greatest waste volumes in the

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[5] Scott, Graham C. *U.S. Economic and Demographic Projections: 1972-1981. National Economic Projections* (Report No. 72-N-2). National Planning Association, Washington, D.C. January 1973.

TABLE IV-5

COSTS FOR PROJECTED FEEDLOTS TO MEET 1977 EFFLUENT STANDARDS

	Beef cattle	Hogs*	Dairy cattle	Total
Number of lots	100,000	330,000	240,000	670,000
		(millions of 1972 dollars)		
Capital costs required, 1972 plants	286	423	416	1125
O&M costs, 1972 plants	38	36	27	101
Total annual cost, 1972 plants	71	92	52	215
Capital in place, 1972	146	183	130	459
Additional capital required, 1972 plants	140	240	286	666
Capital costs required, 1977 plants	300	545	429	1274
O&M costs, 1977 plants	39	46	28	113
Additional capital required, 1977 plants	154	362	299	815
Total annual cost, 1977 plants	74	118	55	247

*1969 Department of Agriculture data include feedlots with a gross income greater than $2,500.

Source: *Economic Analysis of Proposed Effluent Guidelines, Feedlots Industry*. Development Planning and Research Associates, Inc. Manhattan, Kansas. EPA-230/1-73-008. August 1973.

NOTE: Costs are based on all feedlots meeting 1977 effluent standards.

petroleum industry stem from the refining of petroleum, SIC 2911. A separate treatment procedure was used for the remainder of the industry.

Rubber and Miscellaneous Plastics Products, SIC 30. One treatment configuration was used to handle wastewater from the rubber and plastics classification.

Leather and Leather Products, SIC 31. All significant wastewater volumes from this industry result from the tanning and finishing of leather, SIC 3111. Treatment provided this category was based on plants that process skins of cattle, pigs, and sheep.

Stone, Clay, Glass, and Concrete Products, SIC 32. The most significant quantities of wastes in stone, clay, glass, and concrete products stem from the production of cement, SIC 3241. A total containment treatment scheme was developed for this segment of the industry. Wastes produced in other parts of the industry are generally amenable to the same type of treatment, so that only one treatment design was used.

Primary Metals, SIC 33. The major source of wastewater for the primary metals industry is the production of steel, SIC 3311. Treatment of wastewaters arising from seven different steel production processes were included. Treatment schemes were prepared for the primary aluminum industry, SIC 3334, as well as the smelting and refining of several other metals.

Fabricated Metal Products, SIC 34; Nonelectrical Machinery, SIC 35; and Electrical and Electronic Machinery, SIC 36. Wastes originating from fabricated metals and the machinery industry can generally be handled by one of two treatment schemes. Four-digit SIC categories producing significant waste volumes were identified and assigned to one of the two schemes.

Transportation Equipment, SIC 37. Treatment of wastes in the transportation equipment industry poses a difficult problem because of the integration of many manufacturing facilities. Treatment of wastes from the motor vehicle industry was developed based on average waste flows identified in recent EPA reports.

CAPITAL IN-PLACE

The amount of water pollution abatement equipment in use was determined in order to compute the amount of additional investment required to meet the 1977 effluent standards.

TABLE IV-6

CAPITAL IN PLACE FOR INDUSTRIAL WATER POLLUTION CONTROL EQUIPMENT

SIC code no.	Industry	Total initial 1968	1969*	1970*	1971*	1972*	Total
			(millions of 1972 dollars)				
02	Animal feedlots†					459	459
20	Food and kindred products	155	28	40	50	52	325
22	Textile mill products	42	6	7	13	6	74
24	Lumber and wood products†	11					11
26	Paper and allied products	219	79	73	113	114	598
28	Chemical and allied products	733	37	84	151	189	1,194
29	Petroleum refining and related industries	291	133	155	190	123	892
30	Rubber and miscellaneous plastics products	5	4	22	25	29	85
31	Leather and leather products†	11					11
32	Stone, clay, glass, and concrete products	21	31	28	26	39	145
33	Primary metals	260	138	148	124	93	763
34	Fabricated metal products	290	24	27	17	35	393
35	Nonelectrical machinery	20	25	44	33	49	171
36	Electrical and electronic machinery	44	19	30	34	32	159
37	Transportation equipment	29	45	60	34	43	211
	Total	2,131	569	718	810	1,263	5,491

*Based on *Annual McGraw-Hill Survey of Pollution Control Expenditures*, 4th, 5th and 6th editions.
†Not covered by the McGraw-Hill Survey.

The determination of capital in-place was made by modifying the method used in the 1972 *Economics of Clean Water*. Data on water use per employee and the number of plants in each industry group using a specific treatment process were obtained from *Water Use in Manufacturing*. This information was combined with new capital cost curves for each treatment process to yield cost estimates of the capital in place. These costs, based on 1968 values, were then updated with figures from McGraw Hill's annual surveys of pollution control expenditures.[6] The resulting estimates of pollution control capital in-place are presented in Table IV-6. The total for all industrial groups is $5.5 billion.

CAPITAL COSTS OF INDUSTRIAL WASTE TREATMENT

The total capital investment required of the existing industrial structure to provide waste treatment consistent with 1977 effluent guidelines is estimated to be $13.5 billion (Table IV-7). Thus the net capital requirement is the difference between the $13.5 billion and the capital in-place, $5.5 billion, or $8.0 billion.

The estimate is based upon Scenario 3 in which plant efficiencies are moderately increased

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[6] McGraw Hill Publications. 4th, 5th and 6th *Annual McGraw-Hill Survey of Pollution Control Expenditures*. New York.

TABLE IV-7

COSTS FOR EXISTING PLANTS TO MEET 1977 EFFLUENT STANDARDS
(Scenario No. 3)

SIC code no.	Industry	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)		
02	Animal feedlots	1,125	101	215
20	Food and kindred products	1,210	354	508
22	Textile mill products	581	122	196
24	Lumber and wood products	780	277	376
26	Paper and allied products	1,399	165	343
28	Chemicals and allied products	1,943	165	412
29	Petroleum refining and related industries	1,422	149	207
30	Rubber and miscellaneous plastics products	311	118	157
31	Leather and leather products	192	39	63
32	Stone, clay, glass, and concrete products	945	19	139
33	Primary metals	1,590	67	269
34	Fabricated metal products	705	40	129
35	Nonelectrical machinery	524	34	101
36	Electrical and electronic machinery	427	19	73
37	Transportation equipment	346	12	56
	Total	13,500	1,681	3,244

over 1968 levels. The estimate includes the value of waste treatment facilities already inplace. It does not include allowances for inplant modifications that may provide equivalent control for less cost, nor does it impose the conditions that require any theoretical or arbitrary modification of existing practice. Instead, it represents a reasonable extension of practices currently employed in substantial segments of each industry.

Capital requirements are distributed through the various manufacturing sectors in a manner that strongly reflects the sector's water use characteristics (Table IV-4). The requirements have a loose correlation with output values.

ANNUAL COSTS OF INDUSTRIAL WASTE TREATMENT

The total annual cost associated with Scenario 3 is $3.2 billion (Table IV-7). The annual costs consist of O&M, debt service, and replacement. The usual preoccupation with initial capitalization of waste treatment works tends to overshadow the importance of continuing annual costs. Once installed, facilities incur annual costs that over a 20-year period may amount to five times the cost of the initial facilities. At current rates, interest accounts for a large, if not the largest, share of the annual charges. Nearly 40 percent of the annual costs of the waste treatment system modelled can be attributed to interest payments on the outstanding debt. O&M costs account for 35 percent of the annual cost. Major and minor replacements account for the remaining 25 percent.

Unfortunately, there is little evidence available upon which to gauge the rate at which industrial waste treatment works are actually replaced. A 5 percent figure was assumed, the same rate as used in the analysis for the 1972 *Economics of Clean Water*. It is considered reasonable in that it takes into account the rated operating life of components and the demonstrated industrial preference for short-term application of capital. An interest rate of 7.7 percent was assumed, the same rate used in the 1972 analysis.

ALTERNATIVE SCENARIOS

Although the cost analysis and most of the discussion presented here pertain to Scenario 3, which is believed to be most likely to occur, it is important to review results of the other five water use scenarios (Tables IV-8 through IV-12).

The tables reveal that industrial costs in the six scenarios vary considerably. For example, the cost difference between Scenarios 1 and 6 for transportation equipment is 290 percent; for nonelectrical machinery, it is 270 percent. Conversely, textiles show little difference—only 12 percent. The variations may be attributed primarily to the regional distribution of subindustrial categories and to differences in industrial processes within these categories.

COSTS OF MEETING 1977 EFFLUENT STANDARDS–EXISTING AND FUTURE PLANTS

The discussion to this point has been confined to existing plants. Of major concern, however, are the total costs of meeting the 1977 standards, including the costs for plants to be constructed between now and 1977.

An initial step in the development of the costs was to expand the capital requirements of

TABLE IV-8

COSTS FOR EXISTING PLANTS TO MEET 1977 EFFLUENT STANDARDS
(Scenario No. 1)

SIC code no.	Industry	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)		
02	Animal feedlots	1,125	101	215
20	Food and kindred products	1,273	359	521
22	Textile mill products	597	125	201
24	Lumber and wood products	916	287	403
26	Paper and allied products	1,530	175	369
28	Chemicals and allied products	2,291	175	466
29	Petroleum refining and related industries	1,683	164	234
30	Rubber and miscellaneous plastics products	353	123	168
31	Leather and leather products	192	39	63
32	Stone, clay, glass, and concrete products	1,031	19	150
33	Primary metals	1,773	70	295
34	Fabricated metal products	779	42	140
35	Nonelectrical machinery	583	37	111
36	Electrical and electronic machinery	452	19	77
37	Transportation equipment	417	13	66
	Total	14,995	1,748	3,479

TABLE IV-9

COSTS FOR EXISTING PLANTS TO MEET 1977 EFFLUENT STANDARDS
(Scenario No. 2)

SIC code no.	Industry	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)		
02	Animal feedlots	1,125	101	215
20	Food and kindred products	1,271	359	520
22	Textile mill products	595	125	201
24	Lumber and wood products	840	284	390
26	Paper and allied products	1,495	172	362
28	Chemicals and allied products	1,916	164	407
29	Petroleum refining and related industries	1,612	160	226
30	Rubber and miscellaneous plastics products	341	122	165
31	Leather and leather products	192	39	63
32	Stone, clay, glass, and concrete products	1,013	20	148
33	Primary metals	1,753	70	293
34	Fabricated metal products	776	41	140
35	Nonelectrical machinery	581	37	110
36	Electrical and electronic machinery	444	19	76
37	Transportation equipment	405	13	64
	Total	14,359	1,726	3,380

TABLE IV-10

COSTS FOR EXISTING PLANTS TO MEET 1977 EFFLUENT STANDARDS
(Scenario No. 4)

SIC code no.	Industry	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)		
02	Animal feedlots	1,125	101	215
20	Food and kindred products	1,142	347	492
22	Textile mill products	560	120	191
24	Lumber and wood products	619	259	337
26	Paper and allied products	1,255	154	314
28	Chemicals and allied products	1,549	154	351
29	Petroleum refining and related industries	1,157	133	180
30	Rubber and miscellaneous plastics products	262	108	141
31	Leather and leather products	191	39	63
32	Stone, clay, glass, and concrete products	855	19	128
33	Primary metals	1,403	64	242
34	Fabricated metal products	627	37	117
35	Nonelectrical machinery	460	31	89
36	Electrical and electronic machinery	400	18	69
37	Transportation equipment	271	11	45
	Total	11,876	1,595	2,974

TABLE IV-11

COSTS FOR EXISTING PLANTS TO MEET 1977 EFFLUENT STANDARDS
(Scenario No. 5)

SIC code no.	Industry	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)		
02	Animal feedlots	1,125	101	215
20	Food and kindred products	922	320	437
22	Textile mill products	520	114	180
24	Lumber and wood products	509	240	305
26	Paper and allied products	1,046	140	273
28	Chemicals and allied products	1,146	140	285
29	Petroleum refining and related industries	966	120	160
30	Rubber and miscellaneous plastics products	197	92	117
31	Leather and leather products	165	37	58
32	Stone, clay, glass, and concrete products	637	19	100
33	Primary metals	958	55	177
34	Fabricated metal products	515	34	99
35	Nonelectrical machinery	273	20	55
36	Electrical and electronic machinery	321	16	57
37	Transportation equipment	168	8	30
	Total	9,468	1,456	2,548

TABLE IV-12

COSTS FOR EXISTING PLANTS TO MEET 1977 EFFLUENT STANDARDS
(Scenario No. 6)

SIC code no.	Industry	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)		
02	Animal feedlots	1,125	101	215
20	Food and kindred products	782	298	397
22	Textile mill products	487	109	171
24	Lumber and wood products	447	227	284
26	Paper and allied products	721	116	207
28	Chemicals and allied products	902	127	242
29	Petroleum refining and related industries	515	93	117
30	Rubber and miscellaneous products	117	65	79
31	Leather and leather plastics products	115	34	48
32	Stone, clay, glass, and concrete products	370	17	64
33	Primary metals	481	42	103
34	Fabricated metal products	471	31	91
35	Nonelectrical machinery	217	16	44
36	Electrical and electronic machinery	238	14	44
37	Transportation equipment	143	8	26
	Total	7,131	1,298	2,132

existing plants by industry growth and equipment replacement rates. In making the expansion, that water use and industrial growth are assumed to be proportional. In the long run, this linear relationship might not be true, but it should hold for the fairly short 1973-77 period. The national projected growth rates for each industry were obtained from the National Planning Association's National Economic Projections Series (Table IV-13). Replacement expenditures are based on an assumed 20-year life with straight equipment renewal.

The capital investment that must be made by 1977 to meet the effluent standards totals $18.7 billion (Table IV-14). The capital to be added (the difference between the total and the capital in-place) is $11.8 billion, of which about 40 percent is expected to be in new plants. The total annual costs, including interest and replacement, is estimated to be $4.5 billion.

The capital requirements were assumed to be invested evenly over the 1973-77 period. While some industries invested in 1972 a greater percentage of the capital needed, none is spending the average amount needed to achieve 1977 standards (Table IV-14).

State and Regional Distribution of Treatment Cost. Costs to industry of meeting the 1977 effluent standards for existing plants are summarized by EPA Regions and States in Tables IV-15 and IV-16. Feedlots are not included in the tables because geographical breakdown is not available. The Regional summary shows considerable variation. For instance, the costs for Region V (see Figure IV-2) are more than 11 times those of Region VIII. These variations are understandable, given the uneven distribution of industrial activity throughout the Nation. Similarly, there is great variation in costs among the States—New York has projected annual costs 75 times those of Nevada or South Dakota.

The percentage breakdowns of the national totals for industrial wastewater treatment capital costs, total industrial capital costs, industrial wastewater treatment annual costs and value added by manufacturer are shown in Table IV-17 by EPA Regions and in Table IV-18 by States.

While no direct relationship necessarily exists, those areas with a larger share of capital requirements for pollution control than of capital expenses in general might encounter a greater

TABLE IV-13

PROJECTED GROWTH RATES FOR SELECTED INDUSTRIES (1973-1977)*

SIC code no.	Industry	% increase, 1973-1977
02	Animal feedlots	10.0
20	Food and kindred products	18.3
22	Textile mill products	23.3
24	Lumber and wood products	20.3
26	Paper and allied products	19.5
28	Chemicals and allied products	18.4
29	Petroleum refining and related industries	16.7
30	Rubber and miscellaneous plastics products	18.1
31	Leather and leather products	11.2
32	Stone, clay, glass, and concrete products	11.9
33	Primary metals	11.8
34	Fabricated metals	17.5
35	Nonelectrical machinery	23.1
36	Electrical and electronic machinery	23.1
37	Transportation equipment	18.3

*Scott, Graham C. *U.S. Economic and Demographic Projections: 1972-1981. National Economic Projections* (Report No. 72-N-2). National Planning Association, Washington, D.C. January 1973.

TABLE IV-14

COSTS FOR EXISTING AND PROJECTED PLANTS TO MEET 1977 EFFLUENT STANDARDS (Scenario No. 3)*

SIC code no.	Industry	Total capital needed by 1977	Total O&M costs	Total annual costs	Capital in place 1972	Total capital to be added by 1977	Average capital expenditures needed per year	Capital expenditures 1972†	1972 expenditures as % of average annual needs
						(millions of 1972 dollars)			
02	Animal feedlots	1,274	113	247	459	815	204	n.a.	n.a.
20	Food and kindred products	1,718	503	721	325	1,393	348	68	20
22	Textile mill products	860	181	290	74	786	196	10	5
24	Lumber and wood products	1,123	399	541	n.a.	n.a.	n.a.	n.a.	n.a.
26	Paper and allied products	2,006	237	492	597	1,409	352	149	42
28	Chemicals and allied products	2,761	234	585	1,194	1,567	392	214	55
29	Petroleum refining and related industries	1,991	209	290	892	1,099	275	189	69
30	Rubber and miscellaneous plastic products	441	167	223	86	355	89	31	35
31	Leather and leather products	259	53	85	n.a.	n.a.	n.a.	n.a.	n.a.
32	Stone, clay, glass, and concrete products	1,269	26	187	146	1,123	281	43	15
33	Primary metals	2,133	90	361	763	1,370	342	119	35
34	Fabricated metal products	994	56	182	392	602	105	42	40
35	Nonelectrical machinery	774	50	149	171	603	151	53	35
36	Electrical and electronic machinery	631	28	108	159	472	118	36	31
37	Transportation equipment	491	17	79	211	280	70	62	89
	Total	18,725	2,363	4,540	5,469	11,874	2,923	1,016	33

*Including capital needed for treatment facilities at new plants as well as at existing plants.

†Based on *Annual McGraw-Hill Survey of Pollution Control Expenditures*, 5th and 6th editions.

TABLE IV-15

COSTS FOR EXISTING PLANTS TO MEET 1977 EFFLUENT STANDARDS, BY REGIONS
(Scenario No. 3)*

EPA Region	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)	
I	665	99	188
II	1,271	192	356
III	1,391	150	319
IV	1,722	211	438
V	3,095	352	768
VI	1,730	169	343
VII	442	69	124
VIII	261	41	68
IX	1,041	174	196
X	754	122	218
Total	12,372	1,579	3,018

*Excluding feedlots.

TABLE IV-16

COSTS FOR EXISTING PLANTS TO MEET 1977 EFFLUENT STANDARDS, BY STATES

(Scenario No. 3)*

State	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)	
Alabama	217	24	53
Alaska	29	8	12
Arizona	50	7	7
Arkansas	102	13	28
California	936	160	172
Colorado	87	13	24
Connecticut	136	19	36
Delaware	47	5	10
District of Columbia	4	1	1
Florida	270	32	68
Georgia	290	36	74
Hawaii	40	4	9
Idaho	66	10	18
Illinois	800	91	187
Indiana	351	38	80
Iowa	116	16	32
Kansas	77	12	22
Kentucky	138	18	34
Louisiana	402	39	86
Maine	118	14	29
Maryland	123	18	33
Massachusetts	269	44	79
Michigan	604	71	148
Minnesota	162	27	48
Mississippi	127	15	31
Missouri	204	32	59
Montana	60	11	18
Nebraska	45	9	16
Nevada	15	2	3
New Hampshire	60	8	16
New Jersey	519	67	130
New Mexico	33	4	9
New York	755	126	223
North Carolina	305	41	80
North Dakota	13	3	6
Ohio	856	80	189
Oklahoma	81	13	24
Oregon	300	48	88
Pennsylvania	968	96	216
Rhode Island	59	10	18
South Carolina	168	18	40

TABLE IV-16 (Continued)

State	Total capital costs	Total O&M costs	Total annual costs
		(millions of 1972 dollars)	
South Dakota	9	2	3
Tennessee	207	25	52
Texas	1,113	98	207
Utah	62	8	16
Vermont	24	3	7
Virginia	172	22	44
Washington	359	58	103
West Virginia	86	10	23
Wisconsin	324	47	90
Wyoming	30	4	8
Total†	12,388	1,580	3,009

*Excluding feedlots.

†Totals differ slightly from those in Table IV-15 due to rounding.

FIGURE IV-2

REGIONAL OFFICES OF U.S. ENVIRONMENTAL PROTECTION AGENCY

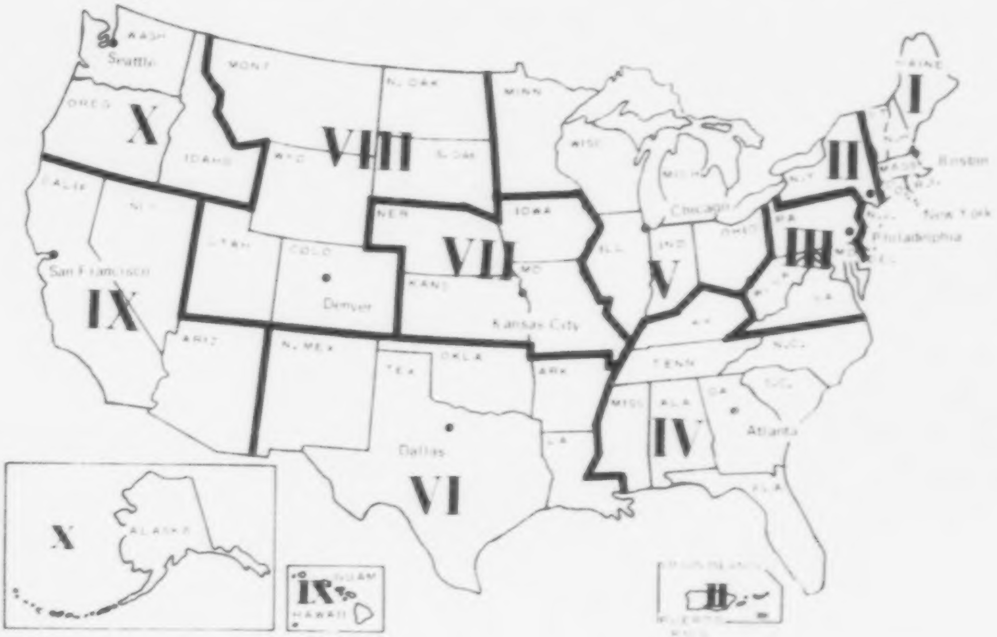
WASH
Seattle
OREG
X
IDAHO
MONT
WYO
VIII
N. DAK
S. DAK
MINN
CALIF
NEV
UTAH
COLO
Denver
San Francisco
IX
ARIZ
N. MEX
NEB
KANS
VII
IOWA
MO
Kansas City
WISC
MICH
Chicago
ILL
IND
OHIO
V
OKLA
TEX
Dallas
VI
ARK
LA
KY
TENN
MISS
ALA
GA
Atlanta
IV
N.C.
S.C.
FLA
VA
W. VA
PA
III
MD
DEL
Philadelphia
N.Y.
II
N.J.
New York
MAINE
I
VT
N.H.
MASS
CONN
R.I.
Boston
ALASKA
X
GUAM
IX
HAWAII
VIRGIN ISLANDS
II
PUERTO RICO

TABLE IV-17

% DISTRIBUTION (BY EPA REGIONS) OF COSTS AND VALUE ADDED

(Scenario No. 3)

EPA Region	Industrial wastewater treatment capital costs*	Total industrial capital costs†	Industrial wastewater treatment annual costs*	Value added by manufacturer†
I	5.5%	5.4%	6.1%	6.9%
II	10.3	11.4	11.7	14.0
III	11.3	11.2	11.0	11.6
IV	14.0	15.1	14.1	12.5
V	24.9	30.5	24.6	30.1
VI	13.9	10.3	11.7	6.6
VII	3.5	3.4	4.3	4.7
VIII	2.1	1.1	2.5	1.3
IX	8.4	8.4	6.3	9.5
X	6.0	2.8	7.3	2.7

*Derived from Table IV-15.

†*Statistical Abstract of the United States*, Department of Commerce. 1972.

burden in diverting capital to the construction of pollution control facilities. Examples of areas with this characteristic are Regions VIII and X, as well as the following States:

Alaska
Hawaii
Idaho
Maine
Montana
New Mexico
Oregon
South Dakota
Vermont
Washington

Other areas might encounter less of a burden of diverting capital to construction of pollution control facilities, given the capital cost and overall level of investment. Regions II, IV, and V fall into this category, as well as the following States:

Arizona
Connecticut
Indiana
Iowa
Kentucky
Maryland
Michigan
New York
North Carolina
Ohio
Tennessee
Virginia

A similar comparison can be made between annual costs of pollution control and value added by industry. In those areas with relatively higher annual pollution control costs than value added, there may be greater changes in wages, prices, and dividends than in other areas. Areas with relatively high annual pollution control in comparison with value added are Regions VI, VIII, and X, as well as the following States:

Alaska
Hawaii
Idaho
Louisiana
Maine
Montana
New Mexico
Oregon
Washington
Wyoming

Those with relatively high value added in comparison with annual costs are Regions II, V, and IX, as well as the following States:

Arizona
California
Connecticut
Delaware
Indiana
Kentucky
Maryland
Massachusetts
Michigan
New York
Ohio
Tennessee

While no detailed set of effects by Region or State can be developed from the data presented in Tables IV-17 and 18, it is clear that significant differences exist. These differences strengthen the hypothesis that there will be a differential burden among States and regions.

TABLE IV-18

% DISTRIBUTION (BY STATES) OF COSTS AND VALUE ADDED

(Scenario No. 3)

State	Industrial waste-water treatment capital costs*	Total industrial capital costs†	Industrial waste-water treatment annual costs*	Value added by manufacturer†
Alabama	1.8%	1.7%	1.8%	1.4%
Alaska	.2	.1	.4	.0
Arizona	.4	.5	.2	.4
Arkansas	.8	.8	.9	.7
California	7.6	7.7	5.7	8.9
Colorado	.7	.7	.8	.6
Connecticut	1.1	1.7	1.2	2.4
Delaware	.4	.3	.3	.4
District of Columbia	.0	.0	.1	.1
Florida	2.2	1.4	2.2	1.4
Georgia	2.3	2.3	2.4	1.8
Hawaii	.3	.1	.3	.1
Idaho	.5	.2	.6	.2
Illinois	6.4	6.7	6.2	7.4
Indiana	2.8	5.2	2.6	3.9
Iowa	.9	1.2	1.1	1.2
Kansas	.6	.5	.7	.8
Kentucky	1.1	1.5	1.1	1.4
Louisiana	3.2	2.5	2.8	1.1
Maine	1.0	.5	1.0	.4
Maryland	1.0	1.4	1.1	1.4
Massachusetts	2.2	2.2	2.6	3.1
Michigan	4.9	6.2	4.9	6.6
Minnesota	1.3	1.4	1.6	1.6
Mississippi	1.0	.8	1.0	.6
Missouri	1.6	1.3	2.0	2.2
Montana	.5	.1	.6	.1
Nebraska	.4	.4	.5	.5
Nevada	.1	.1	.1	.1
New Hampshire	.5	.4	.5	.3
New Jersey	4.2	4.2	4.3	4.7
New Mexico	.3	.1	.3	.1
New York	6.1	7.2	7.4	9.3
North Carolina	2.5	3.4	2.6	2.7
North Dakota	.1	.1	.2	.1
Ohio	6.9	8.9	6.3	7.9
Oklahoma	.6	.6	.8	.5
Pennsylvania	7.8	6.9	7.2	7.3
Rhode Island	.5	.4	.6	.5
South Carolina	1.4	1.6	1.3	1.2
South Dakota	.1%	.0%	.1%	.1%
Tennessee	1.7	2.4	1.7	2.0
Texas	9.0	6.3	6.9	4.2

TABLE IV-18 (Continued)

State	Industrial wastewater treatment capital costs*	Total industrial capital costs†	Industrial wastewater treatment annual costs*	Value added by manufacturer†
Utah	.5	.2	.5	.3
Vermont	.2	.2	.2	.2
Virginia	1.4	1.7	1.5	1.6
Washington	2.9	1.4	3.4	1.7
West Virginia	.7	.9	.8	.8
Wisconsin	2.6	2.1	3.0	2.7
Wyoming	.2	.0	.3	.1

*Derived from Table IV-16.

†*Statistical Abstract of the United States*, Department of Commerce, 1972.

QUALIFICATIONS

While this assessment is primarily concerned with capital investments, it recognizes that each industry may choose treatment types with higher O&M costs in order to reduce its capital costs. Highly mechanized systems tend to have low annual operational costs, but high initial capital costs. Conversely, less sophisticated systems might be built at lower initial costs, but at the expense of higher operational costs. No effort was made to estimate the optimum balance between these two factors—cost curves depicting average expenditures were used.

Many industries tend to favor waste treatment solutions that minimize capital requirements. Since there are a number of treatment configurations and treatment process combinations that provide equivalent waste control in any given situation, management enjoys considerable latitude in the selection of treatment alternatives. In approaching a possible trade-off between the capital intensive and operationally intensive alternatives, there is reason to favor the latter alternative in those cases that promise capital savings up to—and perhaps even beyond—the point of equal total cost. In such cases, the capital saved may not have to be raised or, if on hand, may be applied to other purposes. Money saved through operating economies, on the other hand, must be accumulated over time to provide the same utility. Available savings, then, are inherently more valuable than potential ones, with the measure of value generally tied to prevailing interest rates. Over the last 3 to 4 years, interest rates have reached high levels not generally seen in the United States since the middle of the nineteenth century. Given the consequent penalty on capitalization and the uncertainty of continued high interest charges, management has a strong incentive to seek out treatment solutions with low capital requirements—even at the expense of otherwise avoidable operational penalties.

In a number of industries, the composition of outputs and the nature of processes may shift rapidly. The operationally intensive alternative may also permit management flexibility. Least-cost solutions that are tied too closely to a particular product or process may carry a high degree of risk. In such circumstances, management may prefer to accept operating cost disadvantages to ensure flexibility. This is probably most evident in segments of the chemical industry where batch processing persists in order to reduce the impact of process change, even though capital intensive, continuous flow production processes may be more efficient.

Tax structures may provide further reason for selection of the operationally intensive alternative. Taxes are frequently designed to make it more advantageous to accept incremental operating costs, all other things being equal. Materials and labor utilized in operations may be offset in the year of the expenditure, while capital must be amortized over time.

Another qualification is that the capital estimates are based on two simplifying assumptions that may not be valid. One assumption is that new capital equipment can be simply annexed to existing equipment as standards become more stringent. This is not always valid, and it is certain that a portion of the presently available equipment is incompatible with what is required to achieve the 1977 standards. A second assumption is that only 12 of the most efficient and commonly used treatment types (Table IV-3) are used to meet standards. There are other widely used treatment processes, but they were not used in the analysis.

The last qualification is the noticeable difference between actual and planned estimates for water pollution control expenditures (Table IV-19). After adjustment for inflation and capital replacement, the actual expenditures for all industries in 1972 was $1.0 billion. In 1973, industry expects to spend an additional $1.7 billion. This increase in investment—70 percent—will probably not be realized, primarily because some industries are inclined to overstate planned expenditures. For example, the paper and pulp industry spent $135 million in 1971. It predicted that it would spend $252 million in 1972. The actual expenditures for 1972, however, amounted to only $149 million, a small increase over the previous year.

IMPACTS OF INDUSTRIAL WATER POLLUTION CONTROL

The installation of wastewater control measures by industry will have a number of broad effects on the economy over and above the improvement of water quality. These effects are difficult to define in detail and next to impossible to quantify accurately. They involve complex

TABLE IV-19

ACTUAL VS. PLANNED WATER POLLUTION CONTROL EXPENDITURES FOR SELECTED INDUSTRIES (1971-1976)*

SIC code no.	Industry	Actual 1971	Actual 1972	Planned 1972	Planned 1973	Planned 1976
		(millions of 1972 dollars)				
20	Food and kindred products	58	68	84	123	145
22	Textile mill products	15	10	12	37	38
24	Lumber and wood products	n.a.	n.a.	n.a.	n.a.	n.a.
26	Paper and allied products	135	149	252	444	172
28	Chemicals and allied products	158	214	219	322	345
29	Petroleum refining and related industries	246	189	297	222	486
30	Rubber and miscellaneous plastics products	24	31	30	46	59
31	Leather and leather products	n.a.	n.a.	n.a.	n.a.	n.a.
32	Stone, clay, glass, and concrete products	27	43	55	44	34
33	Primary metals	134	119	114	193	278
34	Fabricated metal products	21	42	55	75	96
35	Nonelectrical machinery	33	53	97	81	119
36	Electrical and electronic machinery	34	36	35	48	49
37	Transportation equipment	47	62	88	83	69
	Total	932	1,016	1,338	1,708	1,890

*Excluding feedlots. Based on *Annual McGraw-Hill Survey of Pollution Control Expenditures*, 4th, 5th and 6th editions.

factors that frequently interact with each other in ways not yet well understood. However, it is important to attempt to identify significant impact areas as accurately as possible. The major areas discussed here are:

- Municipal treatment of industrial wastewater.
- Impact on energy use.
- Broad environmental effects.

Another area, the economic impact on industry, will be discussed in a later chapter.

Municipal Treatment of Industrial Wastewater. One of the alternatives available to industry for control of water pollution discharges is the use of public (municipal) treatment facilities. According to ***Water Use in Manufacturing***, manufacturing operations using more than 20 million gallons per year discharged slightly more than 7 percent of their water to municipal treatment facilities in 1968. This small portion, however, represented more than 20 percent of the total amount of industrial wastewater treated.

Industry's use of municipal facilities varies greatly depending upon the type of industry and its geographic location. Further, there appears considerable variability in the extent of the treatment provided (primary or secondary, for example) by the public authority. Because of these imponderables, it is difficult to determine whether the level of treatment given industry wastes is adequate for 1977 standards.

The use of municipal facilities by industry requires larger public investment in treatment plants and interceptors, as well as higher O&M costs. Conversely, such use permits industries to avoid making capital investments in wastewater treatment facilities and to take advantage of possible economies of scale associated with larger public treatment facilities.

The 1972 Amendments identify some specific requirements for public treatment of industrial wastes:

- Industrial plants discharging pollutants not susceptible to treatment by the municipal plants will be required to pretreat their discharges.
- The costs of providing additional plant capacity for treating industrial wastes are not eligible for Federal grant funding.
- Industries must pay fairly for treatment services rendered, including the costs of interceptor and collector services.

Because of the many factors involved, it is difficult to forecast to what extent industries will use municipal facilities in meeting the 1977 standards. Presuming the decisions will be influenced greatly by economics, the following factors will probably be most significant:

- *Economy of scale.* Larger plants, both municipal and industrial, are generally more efficient in terms of capital and O&M costs.
- *Integrated treatment.* It may be economical to provide full treatment within an integrated industrial plant in those cases where municipalities require industry to pretreat its wastes.
- *Interest rates.* Interest rates on public indebtedness are lower than for the private sector.
- *Interest charges.* There is no interest charged on that portion of the 75 percent Federal grant covering facilities used by industry.
- *Reliability.* A combined industrial-municipal plant should have less variable inflow and may therefore be more reliable.
- *Cost recovery period.* The cost recovery periods used by industry are generally shorter than those of municipalities.
- *Linkage costs.* The costs of connecting an industrial system to a municipal plant—through private facilities or public sewers—may be substantial.

Taking the above factors into consideration, it is reasonable to assume that smaller industrial plants will tend to utilize municipal treatment while larger ones—particularly those discharging toxic wastes—will use private facilities. The figures on industrial capital requirements in this report are based on the assumption that industries using less than 1 million gallons of water per year will use public treatment plants and those using more than this amount will use private treatment facilities. While there will be exceptions to both assumptions, there should be compensating trade-offs.

Impact On Energy Use. Control techniques currently being applied to treatment systems tend to consume large amounts of energy. When pollution control is installed as an afterthought—as with most existing plants—rather than being designed into an operation as a component activity, the energy efficiency may be relatively low. The greatest impact of industrial wastewater control on energy consumption, therefore, will stem from control of existing plants. The impact will increase with the number of plants controlled and the higher levels of control required.

Generally, the relationship between energy consumption and level of treatment is exponential rather than linear. No attempt is made here to specifically quantify this relationship, primarily because data are not available to support an accurate quantitative analysis. Such an analysis would require detailed information on energy requirements by process for each major industry. EPA is currently attempting to collect such information and it should be available to support future analysis.

To determine the total energy cost of water pollution, one must include the energy inputs required to make the pipes, pumps, and tanks used in the treatment facility. Similarly, one must consider the energy requirements of producing the chemical additives such as chlorine and coagulants.

Despite the problems involved, a recent report estimated that the electrical energy used in providing primary and secondary treatment for *all* wastewater in the United States would be 25 billion kilowatt hours per year, or 1.8 percent of total 1970 electricity use.[7] (About one-third of this energy is for treating residential sewage. The remainder is for treating commercial and industrial wastewater.)

Broad Environmental Effects. Environmental effects of wastewater control include those resulting from the production of energy used in the treatment process and those resulting from ultimate disposal of the residuals removed from the effluent stream.

Industry receives most of its electrical power from plants using fossil fuels or nuclear energy. The major environmental residuals produced by plants using fossil fuels are: (1) particulate matter and sulfur oxides in the exhaust gas stream and (2) waste heat that must be removed by transfer to either water bodies or to the atmosphere. Because of inherently lower efficiency, existing nuclear-fueled plants produce more heat than fossil fuel plants of equivalent size. Nuclear plants also pose radiation hazards.

The major environmental problems of wastewater treatment, however, are concerned with disposal of the materials removed from the effluent stream. These materials are broadly classified as sludge and range from thick liquids to semisolid and solid masses. Sludge is primarily disposed of as solid waste, but in certain cases it can be used for other purposes. For example, the residual materials from brewing are used in animal feeds. Sludge can be used as fertilizer, but the hazardous materials such as heavy metals often present in industrial sludges may prevent their use as fertilizer.

Incineration of sludge reduces the quantity of material requiring disposal and also sterilizes the material by killing pathogens. However, improperly controlled incineration can be a significant source of air pollution, primarily particulate matter. Incineration may be inappropriate if the sludge contains heavy metals or other hazardous materials.

Residuals from wastewater treatment that cannot be incinerated are frequently disposed of on land. Unless proper procedures are followed, such disposal can damage the environment. As the quantities of sludge increase and as land disposal becomes more costly, it will become more economic for industry to attempt to recycle the material in some way.

It appears that imposition of stringent effluent standards on waterborne residuals without consideration of airborne and solid waste residuals would merely change the character of environmental problems rather than solve them. Consequently, control of industrial pollution must focus on an integrated scheme that considers the total cost imposed on the industry and the environmental gains.

THERMAL COSTS

Waste heat in the form of thermal water discharges is now recognized by Federal law as a pollutant.[8] As such, it is subject to control along with BOD, suspended solids, and other types of pollutants. The more important provisions of the 1972 Amendments concerning thermal discharges are:

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[7] Hirst, Eric. *Energy Implications of Several Environmental Quality Strategies.* Oak Ridge National Laboratory. ORNL-NSF-EP-53. Oak Ridge, Tenn. July 1973.

[8] Section 502(6), Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500).

- Studies of effects and methods of control of thermal are required, Section 104(t).
- Best practicable treatment effluent limitations are required by mid-1977, Section 301(b)(1)(A).
- Best available treatment effluent limitations are required by mid-1983, Section 301(b)(2)(A).
- Effluent limitations to attain and maintain water quality are required, Section 302(a).
- Thermal water quality criteria must be established or revised for all navigable waters, Section 303(a).
- Water quality limited segments must be identified for thermal discharges, and thermal load allocations must be established where effluent limitations are not stringent enough, Section 303(d).
- Thermal water quality guidelines are required, Section 304(a).
- Thermal effluent limitation guidelines are required, Section 304(b).
- Applications for waiver of too stringent thermal effluent limitations must be reviewed and acted upon, Section 316(a).
- Thermal discharge standards of performance for new sources must be promulgated, Section 306(b)(1)(B).
- State certification for a thermal discharge is required, Section 401.
- Thermal discharge permit is required, Section 402(a).
- Thermal discharge pretreatment standards must be promulgated, Section 307(b).

These provisions, while applying to all types of thermal pollution, place major emphasis upon pollution resulting from industrial activity. This section of the report analyzes industrial thermal impacts, especially the costs of controlling thermal pollution from utility steam-electric generating plants. Thermal pollution from other plants is not included primarily because thermal guidelines for their operations have not been drafted, and adequate costs data are not available. The omission does not negate the value of the analysis, however, since electric utilities account for 80 percent of all cooling water used in the Nation.

SOURCES OF INDUSTRIAL THERMAL POLLUTION

Approximately 50 trillion gallons of water were used for cooling and condensing purposes in the United States in 1968. That was roughly 12 percent of the total flow in the Nation's streams and rivers and accounted for nearly 80 percent of the total water used by American industries. The 50 trillion gallons are broken down as follows:[2,9]

Steam-electric power plants (utilities)	80%
Electric power generation—in-house (industrial)	6%
Industrial processes	14%
	100%

Six large industrial users of cooling water—other than utilities with steam-electric generating plants—are listed in Table IV-20. The six used 52 percent of the industrial water used for air conditioning, 79 percent of the water used for steam-electric power generation, and 84 percent of the water used for other cooling purposes. Although the amount of water used is a valuable indicator of thermal pollution, a complete evaluation must examine other factors such as total heat outputs and discharge temperatures. Also, the characteristics of the receiving bodies of water must be taken into consideration.

None of the Federal/State water quality criteria on temperature allows receiving waters to be raised above 100°F. Since high temperature discharges could result in temperature increases exceeding this limit (or a lower required limit), the Refuse Act Permit Program applications for EPA Region IV were searched for high temperature discharges. Those exceeding 110°F are displayed in Table IV-21. The list suggests that a number of industries, other than those using large volumes of cooling water, may present thermal pollution problems.

Assessment of the cost of abating industrial thermal pollution (other than that associated with public utility power plants) is not presently

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[9] Parker, F.L. and P.A. Krenkel. *Thermal Pollution: Status of the Art.* Nashville, Tenn. 1969. p. 1-2.

TABLE IV-20

COOLING WATER USED BY SELECTED INDUSTRIES (1968)*

SIC code	Industry	Air conditioning	Steam-electric power generation	Other cooling	Total use	Use for cooling as percent of total
			(billions of gallons)			
2621	Paper mills, except building paper	8	248	97	1,194	30%
2631	Paperboard mills	8	141	107	722	15
281	Industrial chemicals	30	613	2,075	3,368	65
282	Plastics materials and synthetics	56	61	372	635	59
2911	Petroleum refining	3	167	1,056	1,427	74
331	Blast furnace, basic steel products	25	1,147	2,046	4,392	47
	Six industry total	130	2,377	5,753	11,738	49
	Total all industries	249	3,009	6,877	15,466	
	Six industries as a percentage of all industries	52%	79%	84%	76%	

*Water use measured by intake. Reuse or recirculation not included.
Source: *1967 Census of Manufactures: Water Use in Manufacturing*. Bureau of the Census. 1971. Table 2A, pp. 7:23 to 7:28.

possible, since effluent limitations have not been established. In addition, identification of the magnitude of the problem is complicated by a number of factors, including the wide variation in industrial processes, the possibility of process changes that could reduce thermal outputs, and the degree of thermal pollution abatement resulting during treatment of other pollutants.

A partial cost could be estimated by computing the costs of abating industry's in-house generation of electric power. Such computations would be difficult to make, however, because of the wide variability of plant size and type of generation (condensing or noncondensing). Also, since 70 percent of the industrial water used for cooling is used for nonpower purposes, only a small part of the total costs would be obtained.

Because of the difficulties in estimating industrial thermal abatement costs and because such costs are relatively small, the remainder of this discussion is confined to utility steam-electric generating plants.

ELECTRIC UTILITY SYSTEMS (SIC 491)

Only about one-third of the energy input to steam-electric power plants is converted to electrical energy. The remaining two-thirds is transferred to the environment, usually by discharging cooling water to receiving waters such as rivers and lakes or to the atmosphere with the aid of a heat rejection device such as a cooling tower.

In a wet cooling tower, water vapor is released to the atmosphere, while in a dry tower it is not. There are very few dry cooling towers associated with power plants in the United States at present because of their relatively high costs. Other heat rejection devices include cooling ponds and canals. Diffusers are sometimes used when heat is discharged directly to the receiving water body. These devices are used to disperse the heat in the receiving water and are not considered a means of heat rejection.

TABLE IV-21

INDUSTRIES DISCHARGING WATER IN EXCESS OF 110°F (EPA REGION IV)*

SIC code	Manufacturing	Number of establishments
20	Food and kindred products	25
22	Textile mill products	41
24	Lumber and wood products	18
25	Furniture and fixtures	13
26	Paper and allied products	30
28	Chemicals and allied products	28
29	Petroleum refining and related industries	7
30	Rubber and miscellaneous plastic products	4
32	Stone, clay, glass and concrete products	7
33	Primary metals	9
34	Fabricated metal products	6
35	Nonelectrical machinery	7
36	Electrical and electronic machinery	2
37	Transportation equipment	3
	Miscellaneous	
144x	Sand	2
491x	Electrical services	21
7211	Hospitals	2
7542	Car washes	2
9711	Military bases	9

*The number and mix of industries exceeding a 110°F discharge temperature may vary considerably among Regions.
Source: EPA's Refuse Act Permit Application computer file 4-12-73.

LEVEL OF CONTROL

About 74 percent of the generating capacity in 1970 used once-through cooling systems, while 13 percent had cooling towers and 13 percent had either cooling ponds or combination systems (Table IV-22).[10]

However, a much larger percentage of the post-1974 capacity is expected to use either cooling towers or combination systems; cooling towers are already planned for 42 percent of those fossil plants and 33 percent of the nuclear plants.[11]

Economic Analysis. The following economic analysis is adapted from a recent EPA report[12] and is based on a preliminary draft of the water effluent limitation guidelines, which are summarized in Table IV-23. The first section of the analysis estimates the maximum impact of the guidelines, based on the cost of installing mechanical draft cooling towers on all plants included in the 1977 and 1983 standards. The second section predicts the reduction in impact based on the expected number of power plants that will not be required to install cooling towers, due to lack of adverse environmental

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[10] Federal Power Commission. Form 67.

[11] 5/72 FPC Printout of Utility Responses to FPC Order 383-2.

[12] Speyer, James M. *Economic Impact of Proposed Effluent Guidelines—Steam Electric Power Plants.* EPA. November 1973.

TABLE IV-22

COOLING SYSTEMS OF UTILITY STEAM-ELECTRIC GENERATING PLANTS[10]

Type of cooling system	% of 1970 capacity
Once-through (fresh water)	51
Once-through (saline)	23
Cooling pond	7
Wet cooling tower	13
Combination	6

impact on the receiving waters, lack of land for construction of a tower, potential adverse impact of salt water drift, or ability to comply with guidelines using less expensive abatement measures.

The maximum impact analysis is based on these major assumptions:

- Demand for electricity will increase by 7.2 percent per year between 1970 and 1980, by 6.7 percent per year between 1981 and 1985, and by 6.6 percent between 1986 and 1990.
- Thermal discharges will be abated by installation of closed cycle cooling systems according to the schedule shown in Table IV-23.
- The cost of closed cycle cooling systems will be equal to the cost of mechanical draft cooling towers.
- Existing plants with cooling towers will incur no additional expense to meet the thermal guidelines.
- Previously planned (before October 1973) expenditures for new plant cooling towers will be considered part of the cost of meeting the thermal guidelines.

Impact on Utilities. The unit cost estimates used in the impact analysis are summarized in

TABLE IV-23

PROPOSED EFFLUENT GUIDELINES FOR THERMAL DISCHARGES FROM UTILITY STEAM-ELECTRIC GENERATING PLANTS[*]

Type of unit	Existing units		Units to be built
	1977	1983	
Large base-load[†]	No discharge	–	No discharge
Small base-load[‡]	No limitation	No discharge	No discharge
Cyclic[**]	No limitation	No discharge	No discharge
Peaking[††]	No limitation	No limitation	No discharge

[*] EPA is currently considering several alternative sets of effluent guidelines that would change the date by which various categories of existing power plants would have to comply with the no discharge limitation.

[†] Units with average boiler capacity factors greater than 0.6 that won't be retired before July 1983; all nuclear units; all units placed under construction after October 1973.

[‡] Units in plants less than 25 megawatts or in systems with a capacity of less than 150 megawatts.

[**] Units with capacity factors between 0.2 and 0.6 that won't be retired before July 1989.

[††] Units with capacity factors less than 0.2

TABLE IV-24

UNIT COSTS FOR UTILITY STEAM-ELECTRIC GENERATING PLANTS[13]

Item	Costs ($/kilowatt of plant capacity)	
	Fossil fuel	Nuclear
	(1970 prices)	
Capital costs of cooling towers*		
Existing units	15	18
New units	7	10
Capital costs for replacement capacity		
1977 peaking units	90	90
1983 baseload units	170	260
Annual operating costs for replacement capacity		
1977 peaking units	42	42
1983 baseload units	30	12

*Costs of constructing and connecting cooling towers.

Table IV-24.[13] The table shows that the cost of installing cooling towers in existing plants is about double that for new plants. Table IV-25 shows that the total capitalized expenditures required to implement the guidelines are $9.5 billion for the 1977 standards and an additional $5.8 billion ($15.3 billion total) for the 1983 standards. The guidelines will increase the total capital expenditures of the electric utility industry by 10.0 percent between 1973 and 1977; by 1983 an additional 4.2 percent increase in total capital expenditures will be required.

The utilities will finance the expenditures for pollution control equipment through internal sources (for example, depreciation, retained earnings, tax deferrals), as well as external sources (for example, long-term debt, preferred stock, common stock). The utilities could finance an estimated 36 percent of the (1973-83) capital expenditures through internal financing, while the remainder would have to come from external sources.[14] If the investor-owned utilities were to maintain their current capital structure (typically, 55 percent long term debt, 10 percent preferred stock, and 35 percent common equity), the external financing would be obtained in the following way:

	Financial requirements 1973-83 (billion dollars)
Long term debt	5.4
Preferred stock	1.0
Common equity	2.6
Total	9.0

The key assumption of this analysis is that the utilities will be able to obtain the required external financing. While it is difficult to conclusively prove that the capital will be available, there is no evidence to disprove this assumption. The utilities were able to increase the level of capital investment by 11 percent per year in the 1960's even though the industry's coverage ratio

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[13] *Development Document for Proposed Effluent Limitation Guidelines and New Source Performance Standards for the Steam Electric Power Generating Point Source Category*, Burns and Roe, Inc. EPA contract No. 68-01-1512. September 1973.

[14] *Economic and Financial Implications of the Federal Water Pollution Control Act of 1972 for the Electric Utility Industry*. Temple, Barker & Sloane, Inc. Boston, Mass. EPA contract No. 68-01-1582. September 1973.

TABLE IV-25

IMPACTS OF PROPOSED THERMAL EFFLUENT LIMITATIONS ON UTILITY STEAM-ELECTRIC GENERATING PLANTS

Impact	1977 Standards	1983 Standards*
Financial effects		
Added capital investment (billions of 1973 dollars)	9.5	15.3
Percent increase (%)	10.0	4.2
Price effects		
Increased revenues per year (billions of 1973 dollars)	2.0	3.0
Price increase (mills/kilowatt-hour)	0.8	0.9
Price increase (% production costs)	6.4	5.8
Price increase (% cost to final user)	3.2	2.9
Capacity penalty		
Total capacity penalty (megawatts electrical)†	8,200	14,900
% of national capacity	1.5	1.9
Fuel penalty		
Total fuel penalty (million tons coal equivalent)‡	18	33
% of national demand for energy	0.5	0.7

*Cumulative effect of 1977 and 1983 standards.

†Total replacement capacity needed to run the cooling towers and to compensate for capacity lost due to increased turbine back pressure.

‡Total increase in demand for nuclear and fossil fuel expressed in million Btu, based on coal having a heat value of 24 million Btu/ton.

(income before Federal income taxes and interest charges divided by total interest charges) fell from 5.11 in 1961 to 3.03 in 1971. The investment required to meet the effluent guidelines will have an insignificant effect on the industry's coverage ratios in 1977 and 1983:

	Coverage ratios	
	1977	1983
Without pollution control expenditures	3.06	2.93
With pollution control expenditures	3.00	2.92

In the past, the electric utility industry has been regulated to ensure an adequate rate of return on its common equity. This analysis assumes that the regulatory agencies will allow the utilities to raise prices to recover the increased operating and fixed charges associated with the standards. Therefore, the profitability of the electric utility industry in terms of rate of return on common equity should not be reduced by implementation of the standards. Actually, by realizing a rate of return on the increased investment in pollution control equipment, the total after-tax profits in pollution control will increase:

	Net income after taxes (billion dollars)	
	1977	1983
Without pollution control expenditures	6.7	14.2
With pollution control expenditures	7.1	14.9

National Impact. To finance the operating costs and fixed charges associated with the capital investment, the utilities will have to raise the price of electricity. Based on the previously stated assumptions, the total cost to the consumers of electricity will be $2.0 billion per year by 1977 and $3.0 billion by 1983. The price increase needed to generate the additional revenues will be 0.9 mills/kilowatt-hour by 1983. The importance of this price increase should be evaluated both in terms of its effect on cost of power at the generating plants and on the cost of power to the ultimate consumer. Thus, while the utility industry's production costs will increase 6.4 percent by 1977 and an additional 5.8 percent by 1983, the cost of power to the final user will increase by only 3.2 percent by 1977 and 2.9 percent by 1983.

The increase in the price of electricity will have an effect on the price of other goods and services. The average price increase is expected to be small, however, since purchases of electric power account for only about 0.8 percent of the total value of industrial shipments.[15] While the impact will be larger on the price of products that are power intensive, there are only six industrial classifications in which electric power costs amounted to 5 percent or more of the total value of shipments (Table IV-26). Even if the increased power costs are completely passed on to the final consumer, the final price of the most power-intensive products will increase by less than 0.5 percent.

The water effluent guidelines will impact the community directly through increased prices for electricity and indirectly through price increases for final goods and services. The guidelines would increase the average residents' monthly electricity bill $0.78 by 1977 and $1.25 by 1983.

Installation of cooling towers will require the construction of new capacity to generate power to run the cooling towers and to compensate for the loss of efficiency due to the increase in turbine back-pressure. This analysis assumes that in 1977 the utilities will provide this increased capacity through the construction of gas-turbine units or the postponement of scheduled retirements. However, by 1983 the utilities will be able to construct large fossil and nuclear plants to replace the lost capacity.

The total capacity penalty will be 8,200 megawatts electrical by 1977 and 14,900 by 1983. This projected capacity loss will increase the national demand for generating capacity by 1.5 percent by 1977 and 1.9 percent by 1983.

A fuel penalty is associated with the increased capacity. This penalty results primarily from additional fuel required to operate the closed cycle cooling systems and to compensate for loss of efficiency. The fuel penalty will be approximately the equivalent of 18 million tons of coal by 1977 and 33 million tons by 1983 (total increase in demand for nuclear and fossil fuel expressed in million Btu, divided by a heat value of 24 million Btu/ton). This penalty amounts to an increase in the national demand for energy of only 0.5 percent by 1977 and 0.7 percent by 1983. Thus, the thermal effluent guidelines should not significantly increase the imbalance between national energy demand and domestic supply.

Impact of Legal Exemptions. The above estimates are based on the cost of installing mechanical draft cooling towers on all plants included in the 1977 and 1983 standards (Table IV-23). However, the number of plants that will actually be required to install mechanical draft cooling towers will be considerably less due to the following factors:

- Exemptions under 316(a) where alternative cooling systems are capable of assuring the propagation of a balanced biotic community.
- Exemptions due to lack of land or adverse environmental impact from salt water drift.
- Ability of some power plants to comply with the guidelines by installing less expensive closed cycle cooling systems such as cooling ponds and spray canals.

In order to estimate the number of plants that would fall into each of these categories, it would be necessary to have at least the following information for each plant:

- Feasibility of assuring a balanced biotic community with alternative cooling system.
- Maximum acreage the utility owns that could be made available for closed cycle cooling system.
- Projected concentration of salt water drift.

While at the present time information has not been compiled for the last two factors, an analysis was made of the impact of exemptions under section 316(a) of the 1972 Amendments.

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[15] *Possible Impact of Costs of Selected Pollution Control Equipment on the Electric Utility Industry and Certain Power Intensive Consumer Industries.* National Economic Research Associates, Inc. New York. 1972.

TABLE IV-26

ELECTRIC POWER COSTS FOR SELECTED INDUSTRIES

SIC code	Industry	Electric power costs as a percent of value of shipments*	Total electric power purchased plus net generation (million kw/hrs)
2819	Atomic Energy Commission plants†	16.26%	29,827.7
3334	Primary aluminum	11.40	53,604.9
3313	Electrometallurgical products	11.01	11,205.7
2812	Alkalies and chlorine	9.35	12,319.0
2813	Industrial gases	9.10	7,050.4
3241	Cement, hydraulic	5.94	8,418.2
	Six-industry total	10.34	122,425.9
	Other industries	0.69	383,395.0
	Total, all industries	0.79	505,820.9

*Self-generated power is evaluated for each industry at the same cost per kilowatt-hour as it pays to buy electric power.

†Only a part of SIC 2819 (industrial inorganic chemicals). Value of shipments by these plants cannot be isolated.

Source: *1967 Census of Manufactures.* Bureau of the Census. *Volume II, Industry Statistics,* Part 1, pp. 28-42; *Volume II, Industry Statistics,* Part 2, p. 28A-9; *Fuels and Energy Consumed, Special Series* MC (67) S-4, p. 18-SR4.

Electric Energy Purchased, Generated and Used, and Maximum Demands at Major Atomic Energy Commission Installations by Months for 1967 (unpublished table). Federal Power Commission. July 1968.

TABLE IV-27

IMPACTS OF EXEMPTIONS TO PROPOSED THERMAL EFFLUENT LIMITATIONS

Impact	1977 Standards		1983 Standards*	
	Without exemptions	With exemptions	Without exemptions	With exemptions
Financial effects				
Added capital investment (billions of 1973 dollars)	9.5	2.3	15.3	4.4
Percent increase	10.0	2.5	4.2	1.2
Price effects				
Increased revenues per year (billions of 1973 dollars)	2.0	0.5	3.0	0.8
Price increase (mills/kilowatt-hour)	0.8	0.2	0.9	0.3
Price increase (% production costs)	6.4	1.6	5.8	1.8
Price increase (% cost to final user)	3.2	0.8	2.9	0.9

*Cumulative effect of the 1977 and 1983 standards.

The analysis was based on the following assumptions:

- 32 percent of the existing capacity covered under the maximum impact case would have to install cooling towers on 60 percent of the plants' total capacity. The plants could meet water quality standards by operating the cooling towers only 30 percent of the time.
- A new plant that is not planning some type of off-stream cooling will have to install cooling towers on 60 percent of its capacity. The plant could meet water quality standards by operating the cooling tower only 30 percent of the time.
- All plants that are currently planning to install cooling towers will be required to operate the cooling tower 60 percent of the time on 100 percent of the plants' capacity.

As shown in Table IV-27, these exemptions would reduce the required capital expenditure from $9.5 billion to $2.3 billion in 1977 and from $15.3 billion to $4.4 billion in 1983. The projected price increase would fall from 3.2 percent to 0.8 percent by 1977 and from 2.9 percent to 0.9 percent by 1983. The exemptions would reduce the cost to the consumer $1.5 billion per year by 1977 and $2.2 billion per year by 1983.

V. Nonpoint Pollution

Nonpoint sources of water pollution vary considerably in type and stem from a broad range of human activities and natural causes.* The activities may be divided into five broad categories of agricultural-rural, forestry, construction, mining, and urban. In many areas, pollutants stemming from these activities—including sediments, organic wastes, salts, minerals, acids, and chemicals such as pesticides, herbicides, and fungicides—constitute a problem equal to or exceeding that of point source pollution.

Singly and in combination, these pollutants present a broad range of problems. In many Western streams, dissolved solids present the most pernicious problem. The increasing salinity of the Colorado River, for instance, threatens use of this important water source for agricultural as well as municipal and industrial purposes; most of the salinity stems from nonpoint sources—47 percent from salt springs and other natural sources, and 38 percent from irrigation. In Appalachia and other coal-producing areas, acid mine drainage often constitutes the most intractable problem. An estimated 20,000 acres of lakes and more than 12,000 miles of streams suffer damage from mine discharge or drainage. Sediments and other nonpoint source pollutants similarly present a variety of problems.

As Federal and State pollution control policies have developed, most attention has been directed toward point sources of pollution. Nevertheless, certain States such as Iowa have shown leadership in the control of nonpoint sources. At the Federal level, the 1972 Amendments took initial steps to develop a nonpoint source control program.[1] The Amendments require EPA to develop information on the nature and extent of nonpoint sources of pollution and the means to control such pollution from a range of activities. Similarly, the Amendments require States to submit reports on nonpoint sources of pollution, and regional planning and operating agencies to recommend and develop control programs.

EPA has published the required series of reports on the nature and extent of nonpoint sources of pollution. Four are based on the types of activities that produce such pollution: agricultural, silvicultural, mining, and urban and rural construction.[2] Three cover unique problem areas that may cut across these types of activities: disposal of pollutants in wells or subsurface excavations, salt water intrusion, and hydrographic modification.[3] A final report covers analytic methods for identifying and evaluating the various sources of nonpoint pollution.[4]

In none of these reports, however, is there significant coverage of control costs and economic impacts. The omission may be attributed primarily to a paucity of reliable information. In an effort to correct, in part, the information deficiency, EPA contracted with Iowa State University to study the costs and

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*Nonpoint sources of water pollution are not defined by the 1972 Amendments. EPA considers all sources to be nonpoint that are not subject to National Pollution Discharge Elimination System permits.

[1] Sections 303(e), 304(e), 305(b), and 208, Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500).

[2] *Methods and Practices for Controlling Water Pollution from Agricultural Nonpoint Sources*, EPA-430/9-73-015; *Processes, Procedures, and Methods To Control Pollution Resulting from Silvicultural Activities*, EPA-430/9-73-010; *Processes, Procedures, and Methods To Control Pollution From Mining Activities*, EPA-430/9-73-011; *Processes, Procedures, and Methods To Control Pollution Resulting From All Construction Activity*, EPA-430/9-73-007.

[3] *Ground Water Pollution From Subsurface Excavations*, EPA-430/9-73-012; *Identification and Control of Pollution From Salt Water Intrusion*, EPA-430/9-73-013; *Control of Pollution Caused by Hydrographic Modifications*, EPA-430/9-73-017.

[4] *Methods for Identifying and Evaluating the Nature and Extent of Non-Point Sources of Pollutants*, EPA-430/9-73-014.

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impacts associated with two major agricultural pollutants—sediment runoff and nitrogen fertilizer.[5] The remainder of this chapter discusses the results of that study.

THE PROBLEM

As the real prices of capital inputs such as fertilizers and equipment have declined, the American farmer has used them widely and intensively, substituting them for both land and labor. As a reflection of these declines, the ratio of the index of fertilizer price to the index of farm crop prices declined from 0.98 in 1940 to 0.64 in 1971. Similarly, the ratio of the farm machinery price to farm labor price declined from 1.19 in 1940 to 0.50 in 1971.

With modern technology and substitution of capital for land, the Nation's relative land supply is greater than at any time in the last 100 years. Cropland has remained relatively constant over the past two decades, but total crop output has increased nearly 40 percent. The same crop output could have been produced under a less intensive production pattern, perhaps reducing the amount of runoff and contamination accordingly. Until 1973, however, Federal programs encouraged the trend toward more intensive farming, with an attendant increase in use of chemicals and similar inputs, by guaranteeing prices (coupled with restricting acreage), subsidizing irrigation development, and providing tax advantages.

While chemicals and similar inputs increase productivity, they can also have adverse environmental impacts. One impact is direct—unused fertilizers and organic chemicals flow into streams and underground water supplies. Another major impact is indirect. Fertilizers and pesticides lessen the need for rotational systems, forages, and mechanical practices. Hence, row crops can be grown more intensively and even continuously on the same fields, and the land loses more water and sediment. The sediment not only contaminates streams, but—along with water runoff—it also provides the transport mechanism by which a greater proportion of residual fertilizers and pesticides are carried into streams.

Technological and economic development of agriculture has also had beneficial effects on the environment, because it has resulted in fewer acres farmed and better use of less erosive lands. Substituting machines for animals means that less land is needed for feeding working animals and that tractors are polluting an average of only 500 hours per year compared with animals that generate wastes year-round.

STUDY DESIGN

The Iowa Study examines supply capacity, productivity, farm income, food prices, and other economic impacts that might prevail under a selected set of environmental policies for agriculture. The study focuses on the year 2000, a period long enough to allow additional domestic and export demands for food to impinge on agriculture and to allow sufficient time for agriculture to adjust to new environmental restraints.

The following basic assumptions were made:

- A free market will exist for commodities included in the analysis.
- Existing technology will be applied increasingly in crop and livestock production.
- Per capita imports of agricultural commodities will be maintained at recent levels.
- The national population will be 280 million in the year 2000 (Bureau of the Census, level D estimate).

The free market assumption permits efficient production of agricultural commodities through crop and livestock allocation and through optimal use of water and land resources. Constraints are imposed on agricultural production, however, in the form of environmental policies, food and fiber demands, and a given land and water resource base.

The study incorporates a number of other general assumptions. First, no unexpected or significant jumps are projected in world demand. Second, land previously or currently idled in land retirement programs can be brought back into production. Finally, no further public development of irrigated lands is assumed beyond 1980.

The main objective of the Iowa study is to estimate agriculture's food-producing capacity under a selected set of environmental restraints. The primary sources of pollution from agriculture

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[5] *Environmental Impacts and Costs in Agriculture in Relation to Soil Loss Restrictions and Nitrogen Fertilizer Limitations.* The Center for Agricultural and Rural Development, Iowa State University, Ames, 1973.

TABLE V-1

ALTERNATIVE FUTURES FOR U.S. AGRICULTURE*

Policy model	Farm policy	Soil loss maximum (per acre)	Exports
Model A	Free market	No limit	Average
Model B	Free market	10 tons	Average
Model C	Free market	5 tons	Average
Model D	Free market	5 tons	High
Model E	Free market with no nitrogen limit	n.a.	Average
Model F	Free market with nitrogen limited to 110 pounds/acre	n.a.	Average
Model G	Free market with nitrogen limited to 50 pounds/acre	n.a.	Average

*Assuming a population of about 280 million, the Bureau of the Census, level D estimate for the year 2000.

include soil erosion, soil salts, livestock wastes, and applied chemicals. Pollutants from these sources include plant nutrients, dissolved salts, toxic chemicals and infectious agents such as coliform bacteria. Except for dissolved salts from irrigation return flows, the pollutants are most often characterized by "slug loads," or large amounts of wastes at irregular time intervals. Slug loads from agriculture include enormous quantities of sediments and plant residues that represent the greatest volume of wastes entering surface waters. These wastes originate primarily from cropland and overgrazed pastures. It has been estimated that agricultural land use results in four to nine times more loss of soil than would occur at natural rates.

The evaluation of the impacts of soil loss and nitrogen fertilizer application is restricted in scope. Only sheet and rill erosion from cultivated lands is analyzed. Sediment yields or the total sediment outflow from a watershed or drainage basin are not considered. Nor did the study include direct analysis of livestock wastes and chemicals such as phosphates, insecticides, and herbicides related to nitrogen fertilizer application.

The basic tool of analysis is a detailed model that measures interrelationships among all commodities, resources, and farming regions.[6] The national model incorporates the resources, commodities, and related outputs of agriculture in 223 farm areas, 51 water supply regions, and 30 over-all commodity markets or consumer demand sets.

Seven policy models (alternative futures) are specified in the analysis (Table V-1). Four cover soil loss. The Nation's agriculture is first analyzed in the absence of environmental restraints (Model A). The outcomes are then examined with maximum soil loss (gross erosion) over the entire Nation limited first to 10 tons per acre and then to 5 tons (Models B and C). To place these levels in perspective, losses may range from virtually zero for Class I low erosive lands to more than 150 tons for Class VIII excessively erosive lands (Table V-2). Because exports are important in food production patterns as well as in farmer and consumer food prices, an alternative future (Model D) is examined in which food exports are twice the 1969-71 averages used in Models A, B, and C.

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[6] *National Environmental Models of Agricultural Policy Land Use and Water Quality* (GI-32990), Iowa State University under contract to National Science Foundation.

TABLE V-2

SOIL LOSS FOR AN AGRICULTURAL REGION*

Land class/acres	Soil loss					
	Conventional tillage			Reduced tillage		
	Straight row	Contour	Strip	Straight row	Contour	Strip
	(tons/acre/year)					
Class I/1.0 million (no erosion hazard)	5.0	2.5	—	2.9	1.4	—
Class IIE/1.5 million (slightly erosive land)	12.0	6.0	3.0	6.7	3.3	1.7
Class IIIE/1.1 million (moderately erosive land)	38.9	22.5	11.2	21.8	12.5	6.2
Class IVE/0.3 million (marginal cropping land)	53.8	32.2	16.1	30.1	17.7	8.9
Class VI to VIII/0.1 million (excessively erosive land)	167.1	129.1	—	122.6	104.8	—

*Based on a crop pattern of continuous corn rotation in Region 104, located in Iowa.

The final policy models are evaluated under the restricted nitrogen fertilizer assumption. A base model specifies no restrictions on nitrogen fertilizer application (Model B). Then the outcomes are examined as nitrogen fertilizer is first restricted to an annual maximum of 110 pounds per acre and then to 50 pounds per acre (Models F and G). The 110-pound figure is approximately the level of nitrogen applied to corn in 1969. Fruits and vegetables frequently receive higher applications of fertilizer, while most grains receive less.

SOIL LOSS-EXPORT POLICY MODELS

Soil loss and farming practices under four alternative policy models are summarized in Table V-3. As might be expected, the average soil loss would be highest, 9.9 tons per acre, under Model A, which does not limit soil loss. The study indicates that with no restrictions on soil loss, soil erosion would average 60 tons per acre per year in certain parts of the South Atlantic Region. The lowest loss, 2.8 tons per acre, would take place with a 5-ton maximum soil loss limitation (Model C). Under this level of control, total soil erosion would be reduced to about 0.7 billion tons per year, a reduction of nearly 2 billion tons, or about 73 percent, from the level of Model A. High exports (Model D) would increase total soil erosion about 16 percent over Model C.

The Nation's food and fiber demands (both domestic and export) and soil loss limitation could be met by adoption of conservation practices such as contouring, strip cropping, and terracing. Compared with the base model (Model A), acreages farmed under conventional straight row tillage would decrease, and acreages farmed under conservation would increase, as the soil loss maximum is first imposed at 10 tons per acre and then lowered to 5 tons per acre.

With exports of grains and oilmeals doubled (Model D), cultivated crop land would increase about 10 percent. The 5-ton soil loss restriction, however, could still be met by further applications of conservation practices. Even with the increase in cultivated land, total soil erosion would remain substantially below levels indicated by the no restriction model (Model A).

Land and water use for the four alternative models are summarized in Table V-4. Three

TABLE V-3

EROSION AND ACREAGES UNDER CONSERVATION PRACTICES FOR SOIL-LOSS EXPORT POLICY MODELS

Item (unit)	Model A, no limit	Model B, 10-ton limit	Model C, 5-ton limit	Model D, 5-ton limit and high exports
Erosion per acre (tons)	9.9	4.3	2.8	2.9
Total soil erosion (millions of tons)	2,677	1,132	727	843
Conventional tillage (milllions of acres)				
Straight row	234	165	129	134
Contour	11	33	37	43
Strip crop & terrace	3	19	35	45
Reduced tillage (millions of acres)				
Straight row	21	27	25	28
Contour	0	14	19	26
Strip crop & terrace	0	3	14	19
Total under cultivation (millions of acres)	269	261	259	295
Conventional tillage, straight row (%)	87	63	50	45
Conventional tillage, contour, strip crop & terrace (%)	5	20	28	30
Reduced tillage (%)	8	17	22	25

TABLE V-4

LAND AND WATER USE FOR SOIL LOSS-EXPORT POLICY MODELS

Item	Model A, no limit	Model B, 10-ton limit	Model C, 5-ton limit	Model D, 5-ton limit and high exports
		(millions of acres)		
Total dryland*	283	276	274	310
Total irrigated	31	32	29	30
Unused cultivated lands†	97	105	108	72
		(million acre-feet/year)		
Water consumption	83	83	77	78

*Not including pasture.

†Including unused summer fallow lands.

points are evident from the results:

- Under all policy models studied, both dryland and irrigated acreages of crops would be less than at present.
- Unused cultivated land (including 25 to 30 million acres of unused summer fallow lands) would be substantially greater than at present.
- Projected increases in water use are only slightly higher than in 1965, the most recent year for which data are available.

Even with a high level of exports (model D), the Nation's land and water resources would not be strained. In fact, acreages used for crops would decline under a soil loss limitation because of:

- Changes in land use—that is, shifts to higher yielding lands.
- Higher yields of crops resulting from reduced tillage and treatment practices such as contouring and strip cropping.

Should supply control programs be relaxed in accordance with the assumptions of the study, crop production would shift to the more productive soils and regions of the Nation. Hence, total land use for agriculture (including irrigated acreage) would be reduced, and unused land (including 25 to 30 million acres of unused summer fallow lands) would approach levels substantially higher than at present. In addition, a large amount of relatively unproductive land currently used for pasture (such as permanent pasture, public grazing lands, and woodland pasture) would remain unused under these policy models. The large amounts of unused cultivated lands, however, pose important problems for national policies on agricultural controls and farm prices.

Farm prices under the alternative soil loss-export policy models are summarized in Table V-5. Up to this point, the general conclusion has been that a nationwide soil loss limitation would not have much impact on agricultural output and prices. The results summarized in the table would further support this conclusion. Agricultural production and unit prices under the soil

TABLE V-5

FARM PRICES FOR SELECTED CROP AND LIVESTOCK PRODUCTS FOR SOIL LOSS-EXPORT POLICY MODELS

Item	Model A, no limit	Model B, 10-ton limit	Model C, 5-ton limit	Model D, 5-ton limit and high exports
Crop prices				
Corn	100	100	107	113
Wheat	100	99	103	114
Soybeans	100	101	115	162
Cotton	100	100	112	112
Hay	100	99	101	110
Livestock product prices				
Cattle and calves	100	100	104	110
Hogs	100	100	105	112
Milk	100	100	100	103
Income (returns)				
Land, labor, and water	100	98	99	131
Other	100	101	104	113
Overall	100	100	103	117

loss models are shown in Table V-6 and resource use or values in Table V-7. Although the model doesn't deal explicitly with the way farm income is distributed among producers and with prices of various categories of agricultural land, one can expect soil loss limitation policies to have a very significant impact on localized areas.

With a 10-ton maximum soil loss (Model B), farm prices (crops and livestock) and, hence, food costs would not change significantly. Net farm income, measured as the return on land, labor (including hired labor) and water would decrease slightly. The response to this decrease would generally be to substitute inputs such as fertilizer and equipment for land, labor, and water.

With a 5-ton maximum soil loss (Model C), farm prices would increase, but by a low percentage. Soybeans would experience the highest increase—15 percent. Net farm income under the 5-ton limit would be nearly the same as without a restriction. Much greater increases in farm prices, implied food costs, and net farm income would result with a combination of high exports and 5-ton maximum soil loss limitation (Model D). The price of soybeans, for instance, would increase by 62 percent.

FERTILIZER LIMITATION POLICY MODELS

Use of land and water under the three alternative nitrogen fertilizer limitation policy models is summarized in Table V-8. Restricting nitrogen fertilizer use would result in a substitution of land and water for fertilizer, with a resulting increase in use of both land and water. Unused land, not including unused summer fallow lands, would drop from around 51 million acres with no restriction (Model E) to about 13 million acres with a 50-pound limit (Model G). The 110-pound nitrogen limitation would not strain the Nation's agricultural capabilities under the food and fiber demand implied under these three policy models. The total land use for agriculture would actually remain below 1971 levels. Even under a 50-pound limit, some unused land (not including unused summer

TABLE V-6

FARM PRICES FOR SELECTED CROP AND LIVESTOCK PRODUCTS FOR SOIL LOSS-EXPORT POLICY MODELS

Item (unit)	Average 1969-71[1]			Projected 2000[2]					
						Unit price			
	Production	Value of production	Unit price	Production	Value of production	Model A, no limit	Model B, 10-ton limit	Model C, 5-ton limit	Model D, 5-ton limit and high exports
	(million)	(millions of $)	($)	(millions)	(millions of $)	($)			
Corn (bushels)	4,741	5,540	1.17	6,520	5,650	0.86	0.86	0.92	0.97
Wheat (bushels)	1,490	1,937	1.29	1,916	2,267	1.18	1.17	1.22	1.34
Soybeans (bushels)[3]	1,203	3,318	2.71	2,117	2,768	1.30	1.31	1.50	2.10
Cotton (bales)[4]	10	1,205	0.23	10	818	0.16	0.16	0.18	0.18
Hay (tons)	129	3,158	26.36	249	5,903	23.69	23.41	24.02	26.12
Other crops[5]	–	1,800	–	–	3,996	–	–	–	–
Beef cows (head)	36	–	–	82	–	–	–	–	–
Beef feeding (head)[6]	25	10,924	27.42	61	18,752	24.85	24.86	25.72	27.26
Dairy cows (head)[7]	12	6,751	5.68	8	3,679	3.21	3.21	3.21	3.32
Hogs (hundredweight)[8]	20	4,502	20.79	31	4,643	14.94	14.93	15.66	16.66

[1] Sources: U.S. Department of Agriculture, *Agricultural Statistics, 1972*; U.S. Department of Agriculture, *Cattle on Feed*, January 1973.

[2] Values are expressed in 1970 dollars and do not take into account inflation from 1970 to 2000.

[3] Includes cottonseed in soybean equivalent.

[4] Unit price is per pound of cotton.

[5] Includes sorghum grain, barley, oats, corn, and sorghum silage and pasture. A common unit cannot be used. Pasture not included in average 1969-71 values.

[6] Value and price are for all cattle and calves, including dairy. Price is in liveweight equivalent.

[7] Values and prices represent hundredweight milk production.

[8] Unit price is liveweight equivalent.

TABLE V-7

RESOURCE USE FOR SELECTED CROP AND LIVESTOCK PRODUCTS FOR SOIL LOSS-EXPORT POLICY MODELS

Item	Land	Water	Labor	Feed	Other[*]	Total[†]
			(millions of 1970 dollars)			
Model A—no limit						
Row crops	2,770	51	910	0	7,161	10,892
Close grown crops	894	23	293	0	2,412	3,622
All hay	1,188	81	467	0	3,523	5,259
Pasture	780	7	0	0	866	1,653
Beef cows	0	5	1,350	7,175	3,251	11,781
Beef feeding	0	3	167	4,053	1,663	5,886
Dairy	0	0	916	1,648	2,106	4,670
Hogs	0	0	523	2,067	2,054	4,644
Total	5,632	170	4,626	14,943	23,036	48,407
Model B—10-ton limit						
Row crops	2,599	47	873	0	7,223	10,742
Close grown crops	849	23	291	0	2,409	3,572
All hay	1,121	87	487	0	3,665	5,360
Pasture	820	7	0	0	866	1,693
Beef cows	0	5	1,351	7,161	3,274	11,791
Beef feeding	0	3	167	4,054	1,662	5,886
Dairy	0	0	916	1,652	2,107	4,675
Hogs	0	0	522	2,066	2,055	4,643
Total	5,389	172	4,607	14,933	23,261	48,362
Model C—5-ton limit						
Row crops	2,876	44	872	0	7,433	11,225
Close grown crops	782	16	284	0	2,273	3,355
All hay	1,225	69	512	0	3,929	5,735
Pasture	744	2	0	0	953	1,699
Beef cows	0	3	1,347	7,294	3,323	11,967
Beef feeding	0	3	161	4,325	1,733	6,222
Dairy	0	0	906	1,745	2,049	4,700
Hogs	0	0	527	2,272	2,071	4,870
Total	5,627	137	4,609	15,636	23,764	49,773
Model D—5-ton limit and high exports						
Row crops	4,723	32	972	0	8,878	14,605
Close grown crops	1,370	17	336	0	2,723	4,446
All hay	1,744	91	535	0	4,049	6,419
Pasture	882	2	0	0	867	1,751
Beef cows	0	3	1,345	7,804	3,518	12,670
Beef feeding	0	2	166	4,696	1,724	6,588
Dairy	0	0	907	1,897	2,096	4,900
Hogs	0	0	530	2,552	2,100	5,182
Total	8,719	147	4,791	16,949	25,955	56,561

[*] **Includes all other costs not itemized.**

[†] **Water used by exogenous crops (fruits and vegetables, for example) and water and feed used by exogenous livestock (broilers, sheep, and lambs, for example) are not reported.**

TABLE V-8

LAND AND WATER USE FOR NITROGEN FERTILIZER POLICY MODELS

Item	Model E, no limit	Model F, 110-lb limit	Model G, 50-lb limit
		(millions of acres)	
Total dryland*	255	265	292
Total irrigated	26	26	27
Unused cultivated lands†	51	41	13
		(million acre-feet/year)	
Water consumption	92.0	92.4	96.6

*Not including pasture, orchards, vegetables, and other miscellaneous crops.
†Not including unused summer fallow lands.

fallow lands) would remain for further substitution or other uses. Compared with no limit, the 50-pound limit would result in 14 percent more land being used, a reduction in unused land by nearly 75 percent, and an increase in water consumption of about 5 percent.

With a 110-pound limitation, crop prices would increase by less than 12 percent, and livestock by less than 4 percent (Table V-9). Net farm income would be higher, but so would consumer food costs. Farm prices would be substantially higher under a 50-pound limit than under either no limit or a 110-pound limit, crop prices increasing up to 50 percent and livestock prices up to 28 percent. Resulting net farm income and food outlays also would rise substantially.

IMPLICATIONS FOR FARM PROGRAMS

Restrictions on soil loss and fertilizer use hold important economic implications for farm incomes, commodity supplies, and environmental control programs. To examine these implications, one first has to look at the demand and supply considerations associated with farm products.

Demand for agricultural commodities is basically inelastic. Thus, if farm production is increased by a given percentage, the price received will decrease by a greater percentage; or conversely, should production fall off by a certain percentage, the price received would increase by a greater percentage. Expressed in different terms, farm incomes will increase with reduced production and fall with increased production.

Without price guarantees, farm incomes in the aggregate are not increased by applying fertilizers and other inputs that increase productivity, because the increased production is offset by lower prices. Since no producer is so large that he can significantly influence market prices by his own actions, there is always an incentive to increase production efficiency.

Government farm programs used in recent years to reduce acreage and limit outputs were designed to maintain farm incomes by keeping supplies at a fixed level in relation to demand. Generally, the programs have kept farm income higher than would have been the case in their absence. The same logic has underlain the government programs to increase exports. Exporting a given percentage of commodities (hence removing them from domestic markets) would result in a larger percentage price increase, at least for those commodities sufficiently protected from world market prices.

Of course, as more individual farmers use advance technologies and increase output in a free market situation, market prices will fall by a greater proportion, and total farm income will be reduced accordingly. In the absence of farm supply control programs that materially affect total crop output (and thus maintain higher prices), the individual farmer will be worse off

TABLE V-9

FARM PRICES FOR SELECTED CROP AND LIVESTOCK PRODUCTS FOR NITROGEN FERTILIZER POLICY MODELS

Item	Model E, no limit	Model F, 110-lb limit	Model G, 5-ton limit
Crop prices			
Corn	100	109	150
Wheat	100	106	147
Soybeans	100	104	136
Cotton	100	112	151
Hay	100	102	124
Livestock product prices			
Cattle	100	102	120
Hogs	100	104	128
Milk	100	102	113

unless he continually uses new technologies and produces more to sell at the reduced prices.

Farm production could also be controlled, at least in part, through environmental programs that restrain production. Essentially, farm programs have restricted output by taking part of the Nation's cropland out of production. Some combination of lower productivity and utilization of idle land could restrict available supplies in a manner similar to the land restriction program. Environmental protection measures might be phased in as control programs are eliminated.

The Iowa study reveals that a surplus of land will continue to exist to the year 2000 under the 1969-71 average level of exports. This reserve capacity could be used in combination with environmental protection measures (such as restrictions on fertilizer use) in place of existing government supply control programs.

Such a program is not only possible, but, if designed properly, would result in an efficient use of resources. One reason for the overuse of chemical fertilizers and row cropping is that market prices do not reflect the social cost of their use. Prices reflect neither the cost of eutrophication that may result from the buildup of nitrates nor the adverse effects of sedimentation on recreation and on certain species of fish and wildlife. At this time it is impossible to determine the most efficient combination of inputs, because the full social costs cannot be measured in dollars. It is possible, however, to indicate the potential benefits of an environmental control program and its economic impact.

Reduced Erosion. Results of the study indicate that agriculture has the opportunity to contribute to an improved environment. In general, they indicate that a nationwide soil-loss limitation would have only minor impacts on land and water resource use, farm prices, food costs, and net farm incomes. Soil erosion, however, would be reduced considerably with an attendant improvement in water quality. This reduction would be possible at relatively small cost to farmers, as a group, if adequate time for adjustment were allowed. The reduction would be affected through changes in crop rotations and the adoption of conservation tillage practices such as contouring and strip cropping. Individual farmers, however, may be reluctant to switch from conventional practices for a number of reasons. Reduced tillage practices, as compared to conventional practices, would in most cases, require new or different equipment. Also, weed control can become a problem, and colder soil temperature (which results from reduced tillage) sometimes delays seed germination. Over time, though, it is expected that farmers could make the necessary adjustments.

A doubling of exports over the 1969-71

average would have a much greater impact on resource use, farm prices, food costs, and net incomes than the adoption of a nationwide soil loss limitation. With higher exports, total soil erosion also would increase. But even if the higher level of exports were combined with a soil loss limitation, total soil erosion could still be held to reasonable levels.

Nitrogen Fertilizer Limitations. The results of the study indicate that a mild restriction on the use of nitrogen fertilizer (such as 110 pounds per acre per year) would not strain land and water resources. The substitution of water and land (mostly land) for fertilizer under a 110 pound nitrogen limit would still leave a considerable amount of surplus land and water to meet possible increases in demand. Also, the restriction would result in farm prices above those experienced without a restriction.

With nitrogen fertilizer limited to 50 pounds per acre, the reserve supply capacity of U.S. agriculture would be reduced considerably—nearly 75 percent. Farm prices and consumer food outlays, however, would be expected to increase, some by as much as 50 percent.

Income Distribution and Equity Effects. Environmental control measures that lessen output can increase gross farm income because demand for the basic agricultural commodities is inelastic. This does not mean, however, that all groups of farmers would benefit or have their income protected. The results of the study indicate that certain types and levels of environmental protection measures would have greatly different effects in different regions. Some regions have topography that would not be affected greatly by soil-loss limits. Also, some regions have climatic conditions and crop adaptation that permit meeting crop nitrogen requirements through natural processes of nitrification—the summer fallow wheat areas of the Great Plains, for example. In contrast, certain areas of the Southeast have crop farming on hilly and erodable land. Production from these areas is greatly dependent upon the amount of chemical fertilizer applied. Limits on nitrogen fertilizer application in these areas could reduce crop yields by a greater percentage than offsetting percentage price gains resulting from environmental protection measures or government supply control programs. Agricultural regions based entirely on semiarid grazing lands and beef production generally are not faced with reduction in crop yields and output as environmental measures are taken. Some, however, would face greater competition from those regions that would be forced to incorporate more forages into their rotations (or sod-based rotations) as a means of attaining environmental standards.

Imposition of soil loss and nitrogen application limits would not reduce total national farmer receipts if two conditions were met:

- The farmer's level of production is not lower than under the land retirement programs.
- The farm community must receive payments equal to what it formerly received for removing land from production.

However, income effects would vary widely among the 223 farm regions delineated in the study. Not all of them possess the characteristics needed to have their income improved or maintained under conditions of prevailing farm programs or a free market situation.

Adoption of environmental measures that would just offset and replace government supply control programs would still have a differential effect among regions. As might be expected, areas using little nitrogen fertilizer and having soils and climate causing little soil loss would realize more income, as well as windfall gains in the form of higher land values. Conversely, those areas with yields affected materially by shifts in land use and reduced nitrogen would have less income, even though total revenue would remain constant at the national level.

VI. Benefits From Water Quality Enhancement

INTRODUCTION*

Meeting the water quality goals set by the 1972 Amendments will require expenditures by Federal, State and local governments and by private industry. Given the costs involved, it is important to know what will be received in return, what will be the economic value of enhancing the quality of water resources, and in which locations and for what purposes will abatement efforts be most valuable.

The purpose of estimating benefits is to infer the economic value of pollution control. The market value of most goods and services and factors of production is known by their market prices—that is, the amount that someone is willing to pay for their use. However, normal market transactions are not usually available for valuing water quality. Therefore, the value must be imputed indirectly as it affects the costs of producing goods or the demand for water-related activities. The estimation of benefits is an effort to identify how much water users would be willing to pay for an amount of water quality enhancement if a market existed. For example, consumers would be willing to pay for increased pleasure in recreation uses, and industry and municipalities would be willing to pay to avoid the costs of treating water before they use it.

Estimating benefits at a particular site requires four sequential steps:

- The abatement plan must be specified in terms of the amounts and types of pollutants to be reduced.
- The impact of the abatement plan on the parameters of watercourse quality must be predicted.
- The impact of changes in the parameters on water uses must be estimated.
- The economic value of induced changes in the level of uses and in the increased value of existing uses, plus cost savings because of improved water quality, must be identified.

The first step is required because a benefit study is useful only if estimated benefits can be compared to the costs that produced them. A benefit study is undertaken at a site to compare the value of abatement with the costs of abatement. The effluent guidelines, established under the 1972 Amendments, become the abatement plans. And the projected total effluent releases must be compared to the present level of effluent releases in order to obtain a measure of abatement. The first step is probably the least difficult once the guidelines are established, although the content of some presently released effluents, particularly industrial wastes, is not completely known. Abatement can reduce release of a combination of pollutants such as oxygen-demanding organic wastes, suspended and floating solids, hazardous materials, waste heat, and other chemical substances. Data on abatement plans already undertaken should depend mainly on monitoring effluent streams before and after abatement. For benefit studies of proposed plans, the abatement efficiencies of selected technologies must be inferred from experience elsewhere.

For the second step, a transfer function must be constructed relating pollutant emission quality to changes in ambient conditions. Abatement can affect parameters such as dissolved oxygen, temperature, and chemical concentrations in a wide variety of ways. Some of the effects are well known, but others are not. The effects depend in part on existing water temperature, air temperature, wind, water current and mixing, and other physical and biological characteristics of the receiving waters. In-stream monitoring

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*For a more theoretical and comprehensive discussion of the issues in benefit analysis by EPA, see *Techniques for Cost and Benefit Analysis of Water Pollution Control Programs and Policies*, report to Congress in compliance with Public Law 92-500, January 1974.

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should include several water quality parameters, a number of monitoring sites, since effects can vary widely between nearby points. However, monitoring is so expensive that inferences must be made from samples made at few points and for only a few parameters. This tends to weaken this step in the benefit estimation process.

Probably the most difficult step in benefit estimation is to link changes in water quality parameters and man's potential use of water resources. For this third step, it is useful to classify water uses as withdrawal or in-stream uses. Withdrawal uses include municipal, industrial, and agricultural (irrigation) activities. In-stream uses include commercial fishing, water-related recreation, and navigation. There are also ecological benefits and aesthetic values not directly related to recreation.

The fourth step in benefit estimation is to assign values to use changes. Municipal and industrial water users value improved water quality because it can lower water treatment costs, and farmers and commercial fisherman value it because it increases crop and fishery yields and thus increases their income. Many individuals value improved water quality because it increases the potential for water related activities, aesthetic enjoyment of water courses, and maintenance of the ecological system. Individuals also value improved water quality because it reduces the potential for health hazards.

Each of the four steps must be completed in order to estimate the benefits of a given abatement scheme. The ability to measure benefits is a composite of the four steps. The greatest difficulties lie in the second step, tracing the effects of an abatement plan on water quality parameters, and in the third step, relating parameter changes to man's use of the water. To a large extent, improved benefit analysis depends on better knowledge of how to measure these relationships, but the emphasis here will be on the fourth step of placing a value on the changes in use.

WATER QUALITY AS AN INPUT INTO PRODUCTION

Water quality is important as an input into industrial water uses, municipal (domestic) water uses, commercial fisheries, and agriculture With cleaner raw water, an industry or municipality may incur lower treatment costs or a fishery or farm may be more productive. The approach to measuring the benefits is to estimate the value of lower costs of production and increased productivity resulting from improved water quality.

Industrial Uses. Deviating from prescribed water quality for particular industrial uses can result in damage to equipment, reduced efficiency, reduced product quality, or other economic costs such as reduced yields. Water quality requirements vary widely from industry to industry. For example, water with color would be suitable as boiler feed but unsuitable in the manufacture of clear, uncolored plastics. Because of the wide variations in water quality requirements, benefit estimates for one or two industrial sectors cannot be generalized to all industry in a region or in the Nation.

The benefits from water quality enhancement are probably measured most accurately in industrial water uses. Engineering studies can calculate the cost savings from decreased requirements for water treatment; the cost calculation is facilitated by the use of normal market prices for the inputs that will no longer have to be used. Measuring benefits for more than one firm or for regional or national studies might be done using statistical cost functions, and future cost savings might be estimated through use of population and water use projections—that is, demand projections. If statistical cost functions are not available, then survey and interview techniques could be applied; their accuracy would probably be lower, however.

Municipal Uses. Estimating the benefits of cleaner water to municipal water systems is as straightforward as for industrial water uses, but the engineering studies of damage to equipment and to other factors are not as well developed. Statistical cost functions for particular treatment plants, if applied to plants in other locations, would probably be more reliable than the same procedure in industrial studies because the product, clean water, is much more similar between regions. There is still the problem, however, of variations in natural pollutants. Treatment costs and techniques vary between locations, which makes generalization of a few studies to broader areas unreliable.

Although treatment cost savings can be calculated, it is difficult to relate these benefits to the cost outlays made upstream for waste treatment. Frankel (1965) attempted to make this link using a simulation model of a part of a river.* His results indicate the complexity of the linkage because of hydrologic variations in rivers, both between sites and at the same site over time. Benefit estimates are not useful as a policy guide if they cannot be related to the cost outlays needed to produce them.

There is one national estimate of water supply benefits to domestic users. Tihansky [1973(b)] derived individual functions that relate physical damages from minerals and other pollutants to both household appliances and to water distribution facilities. The effects were converted to economic losses from operating problems and equipment depreciation in a typical household. Average household damages were found to depend on the sources of water supply—whether it was publicly treated surface water, publicly treated groundwater, or private well water. The most economically damaging pollutants were hardness and total dissolved solids. Because these pollutants are partly natural in origin, the portion due to man-made pollutants is difficult to segregate.

Multiple Uses. Some benefit studies do not emphasize one water use but instead study one pollutant in several contexts. Considering both domestic and industrial uses, Brandt (1972) assessed the economic effects of sediment along the Potomac River north of the District of Columbia. Not all of the effects were detrimental, since turbidity in municipal water supply absorbs certain foul-tasting and odor-producing constituents. Hypothetical linear damage functions were used to relate sediment loads to the chemical treatment costs of water supply.

In a more comprehensive geographic analysis, Stoll (1966) estimated annual sediment damages for the United States. Damage categories included reservoir capacity losses, inland navigation route blockages, obstruction of irrigation canals, excess turbidity in public water supplies, and commercial fishery losses. The validity of such estimates is questionable because accurate data on sediment discharge, transport, and subsequent effects do not exist in most regions of the country. Benefits were estimated by using the cost of repairing the damage or removing the obstruction. For example, the cost of dredging was used as a surrogate for damages although firms using a dredged canal or whatever may be willing to pay much more (or less) than these costs. Thus, costs of repair are not an accurate surrogate for benefits.

Commercial Fishing Uses. Commercial fishery losses from pollution have been estimated for small coastal areas, estuaries, and river stretches throughout the United States, but there are only a few national estimates. Bale (1971) estimated total national losses of revenue (dockside) from DDT, mercury, and pathogenic organisms. Fish kills were evaluated by assigning an arbitrary price per fish and assuming that roughly two-thirds of reported kills were commercial species. This assigned value may be modest; further, because fish kills are not carefully monitored, the damage estimates are highly conjectural. Bale calculated the economic losses to the shellfish industry by assuming that only clams and oysters, which are immobile, were reduced in catch. Other species were assumed to avoid pollution. The reduction in potential supply was assumed to be proportional to shellfishing areas closed by pollution. Potential revenue gains used as benefit estimates were calculated from the original price of shellfish. This may be inaccurate since an increase in the national supply should lower prices.

The Council on Environmental Quality (1971) also estimated national revenue losses of commercial (marine) shellfishing; this value is four times as large as Bale's estimate because it included all species caught. The Council's estimate is probably too high because some species, such as lobsters and crabs, can tolerate more pollution than clams and oysters. The fourfold difference in loss estimates indicates that benefit estimation is not far advanced.

Weddig (1972) calculated the impact of mercury restrictions on inland and estuarine fish supply in the United States. He assumed that roughly 1.5 percent of potential domestic supply is lost. An interesting part of this estimate pertains to a potential coho salmon fishery in Lake Michigan. Since it "closed before it began," the real dollar losses to private fishermen are assumed to be nil. By overlooking the social cost of unfilled opportunity and lost option demand, this viewpoint avoided a very difficult measurement problem.

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*References cited are included in a bibliography located at the end of this section.

Agricultural Uses. The salt content of water can have serious economic and social impacts on agriculture by contaminating irrigation water. Callinan and Webster (1971) estimated farm production losses and the social costs of uprooting rural community life by forcing farmers to move. The economic cost of re-establishment was assumed to be a fixed amount per capita and the corresponding "social cost" to be one-fourth of the economic value. These costs were not defined explicitly and apparently included some concept of value in addition to the normal efficiency concept of benefits. Damage to crops may be caused by other factors such as poor farm management, the effects of which were not considered in the study. Finally, farm crop losses are an immediate effect and may not reflect long-term damages. Crops more tolerant of salinity may be substituted in irrigated fields, reducing initial income losses.

Vincent and Russell (1971) presented a more comprehensive analysis of saline water uses. Economic losses estimated were decreased agricultural crop yields, municipal and industrial water treatment costs, corrosion of water supply intake pipes, and reduced palatability of drinking water. The palatability loss referred to consumers' willingness to pay for their taste preferences and hence was more subjective than the other impacts. Because general information on salinity effects was minimal, the authors derived estimates of expected values and probabilities of damage levels by soliciting the opinions of experts.

In a theoretical decision model, EPA (1971) attempted to identify the least cost solution of salinity control. Farmers had five possible responses to saline irrigation water from the Colorado River Basin. Their options varied from no remedial action (with reduced crop yields) to maintenance of past crop yields (with increased water requirements). Nonlinear economic damage curves were formulated for each action, but they were based on minimal data and incomplete surveys of farmers' preferences for action. As a hedge, all damage estimates were made on the conservative side.

Another study of this region, by the Bureau of Reclamation (1969), derived what appear to be high damage values. On the basis of no remedial actions, crop losses were evaluated on the assumptions that the highest valued crops were destroyed and that soil leaching conditions were extreme. Estimates of regional crop damages were based on fixed prices and thus overlooked the possibility that large-scale changes in supply could significantly affect the market prices.

Implications. The ability to estimate benefits varies when water quality is an input in production. Benefit estimation can be quite accurate for a single industrial plant or a municipal water treatment plant. It is less accurate in agriculture because of problems of changing levels of output, of subsidized prices, and in separating natural from man-caused pollutants. Finally, it is probably inaccurate in commercial fisheries because the effects of pollutants are not well known and the price-quantity relationships vary greatly in short time periods as fish supplies change. In addition, benefit studies must be specific to a plant or site to have any validity. Generalization of the results of one study to other sites or plants is usually not valid. National benefit studies must be a summation of the results of many studies and not a generalization from one or a few studies.

WATER QUALITY WHEN CONSUMED WITH ANOTHER GOOD

Clean water is consumed with some final goods. In this case, the benefits of water quality enhancement are measured by the increased willingness to pay for the good consumed with the cleaner water. For example, the additional amount that persons would be willing to pay for a recreational experience on a cleaner lake or river is the relevant concept of benefits.

The primary good for which water quality is important is water related recreation. But a complicating factor is that outdoor recreation is usually a nonmarketed good so that the demand has to be determined from some other activity. There are three main approaches to determining benefits and variations within each method.

One approach is to use market data of private recreation facilities. If a private development is a close substitute for a public facility, then willingness to pay for private recreation is likely to be a valid estimate of the value of the public recreation. Unfortunately, private recreation developments are usually not similar to public ones.

A second approach is to ask potential beneficiaries how much they would be willing to pay to use a particular recreation facility. The critical problem with this approach is that responses to survey questionnaires tend to be biased whenever the respondent believes his answer to be self-serving. For example, a respondent may overestimate his willingness to pay for a recreation area if he believes his answer will encourage a decision to provide more such areas. He may understate it if he thinks he may have to pay. In addition, there is the problem of people making hypothetical choices. The respondent is not as likely to evaluate the consequences of a hypothetical choice as carefully as he would the possible outcomes of an actual choice. In fact, the choice may be made with very little thought since he will not experience the consequences.

The third approach is the travel-cost method. This method derives a market-demand function for a particular recreation site. It bases willingness to pay on travel costs to get to a particular site. However, this approach underestimates willingness to pay to the extent that persons are willing to use their scarce time for travel to the site.

The travel-cost approach has been applied successfully several times and is probably the most useful of the three models. Its most serious difficulty is that it primarily is useful only for calculating benefits on a completed project. Since the method depends on participation rates, the use before and after a change in water quality must be known before willingness to pay for the site can be estimated. This difficulty is serious, since the primary use of benefit estimates is for evaluating proposed projects.

One of the earliest and most comprehensive benefit studies dealt with water quality in the Delaware Estuary. The study, made by the Federal Water Pollution Control Administration (1966), attempted to quantify water quality benefits to recreation, commercial fishing, and domestic water supply. Rough estimates of recreation benefits based on national participation rates and applied to the regional population accounted for the great majority of water quality benefits. Benefits to commercial fishing were significant, although only a small fraction of total benefits. Benefits to domestic water supply were negligible.

In an extension of the Delaware study, Tomazinis and Gabbour (1967) estimated the economic impacts of pollution control on the specific activities of boating, fishing, swimming, and beach picnicking. Like another related study completed earlier by Davidson (1966), they assumed that demand increases linearly with the supply of clean surface water. The major shortcoming of both studies was that total benefits were determined by multiplying the anticipated increased use by a range of essentially arbitrary values. This approach does not represent benefits in terms of willingness to pay, nor is there any reason to suspect it is a good approximation. Nevertheless, useful attendance information was developed.

A rigorous benefit study by Stevens (1966) looked at the relationship between water quality and the value of the Yaquina Bay sports fishery in Oregon. Demand for fishing was estimated by the travel-cost method but modified to include the quality of fishing, which in turn depended on the quality of water. The benefits of cleaner water were estimated by the willingness to pay for sports fishing. The benefit estimation was later successfully questioned by Burt (1969) as underestimating the total willingness to pay.

Despite their limitations, studies such as these have provided useful information and have advanced benefit evaluation. More empirical work based on sound analytical procedures is needed, but rigorous studies tend to be both time consuming and expensive. Data requirements can be staggering and the necessary methodologies highly technical. The value of future studies would be enhanced greatly if results could be legitimately generalized to the regional level. High priority should be given those studies most likely to produce results that can be extended to other situations.

WATER QUALITY AS A FACTOR IN HUMAN HEALTH

There has been considerable research on the impact of inadequate water quality control on human health. Epidemiologic and other health data are now compiled in detail for acute clinical illnesses, however, and they do not exist for subclinical and low-level illnesses such as common diarrhea as related to water quality. Problems arise in that the victim may not report the illness, or the effects may only occur after a period of time has elapsed, making its cause impossible to trace.

Water pollutants are transmitted to man in several ways. Pollutants enter through the public water supply system in the form of such things as chemical impurities, bacteria, and viruses. Second, they enter through the food supply such as a buildup of chemicals in fish. Third, pollutants enter through direct body contact with the water such as in swimming. Finally, pollutants may lead to ecological changes that affect man's physical or psychological health.

The research on health impacts and water quality is concerned with several basic areas:

- Bacteriological parameters of surface water bodies, including discussions of source, survival, and removability.
- General reviews of the incidence, outbreaks, and significance of waterborne diseases.
- Engineering evaluations of health hazards and water quality parameters.
- Studies of specific pollutants such as mineralization, mercury, or coliform bacteria, and their relation to human health.
- Bacteriological parameters and contact recreation.

The emphasis at this time has not yet shifted to the economic quantification of reduced health hazards or risks associated with water pollution abatement.

The value of avoiding sickness or of dying prematurely from polluted water does not fit well into the two previously discussed concepts of benefits. When water is used directly for drinking, cooking, bathing, and swimming, or indirectly in the production of some good, there is a risk of contracting some disease. A person would not use water if he knew that it would make him sick. But he would use water if he knew there was only a small chance of contracting a sickness—that is, he thought perhaps that someone may get sick, but he did not know who. Thus the correct concept of benefits is the amount a person is willing to pay to reduce the risk of getting sick.

Health benefits have been conceptualized in several ways. One is to measure loss in gross earnings. This assumes that there is no benefit in preventing illness for housewives, children, or persons who are retired, on vacation, on welfare, or living on investment income. It is not clear that even persons who are working would be willing to pay *all* of their income losses to avoid being sick. A second measure takes gross income minus consumption expenditure. It is again not clear that persons who are working would be willing to pay only their savings to avoid being sick or dying prematurely. A third measure adds up outlays by sick persons for doctors, hospitals, and medicine. The amount that persons would pay to repair a sickness may be very different from the amount they would pay to reduce the risk of getting sick in the first place.

There is recent but increasing acceptance of the concept of health benefits as being willingness to pay to reduce the risk of contracting a sickness or of dying prematurely, but very little successful work has been done to identify a proxy for this amount for water quality (or for other health situations) (Liu 1972).

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VII. Constraints

This chapter examines some of the potential problems in implementing the 1972 Amendments. A national determination that water pollution control is in the public interest does not eliminate economic and administrative problems. The economic problems of concern in this report are the financial burdens placed on municipalities and industries as they meet the 1977 standards, and the capacity of the construction and equipment supply industries to put in place the required capital without adversely affecting the levels, volume, and prices of construction and equipment, as well as wages and employment in those industries.

FISCAL IMPACT ON LOCAL GOVERNMENT

Localities will not, in general, find it difficult to finance their share of the capital outlays required to construct sewerage facilities. Local agencies will bear, however, the considerably increased annual cost of operating, maintaining, and administering public sewerage facilities and services.

Required Capital Outlays. The 1973 "Needs" Survey indicates that an enormous investment is required to bring the Nation's public sewerage facilities up to an acceptable level. The indicated costs (Table III-5) may be summarized as follows:

Category		Billions of 1973 dollars
I	To meet the "secondary treatment" standards contained in the 1972 Act.	$16.6
II	To provide more stringent treatment when required by water quality standards.	5.7
III	To correct sewer infiltration and inflow.	.7
IVA	To construct new interceptors, forcing mains, etc.	13.6
IVB	To construct new collection sewers in existing communities.	10.8
V	To correct overflows from combined sewers.	12.7
	TOTAL	$60.1

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Projecting Sewerage Capital Expenditures. The results of this latest Needs Survey were meant to serve as a basis for allocating available Federal construction grant funds among the various States. The survey results have not been used directly in projecting capital outlays for sewerage facilities during the next several years. The primary reason is that the individual States and localities developed their estimates of expenditures and completion dates without consideration of the overall amount of funds that might be available. Instead, public expenditures for sewerage construction were projected (Table VII-1) primarily on the following assumptions:

- The remaining unallocated funds ($13 billion) authorized in the 1972 Amendments

TABLE VII-1

PROJECTION OF CAPITAL OUTLAYS ON PUBLIC SEWERAGE CONSTRUCTION, 1974-80

	1974	1975	1976	1977	1978	1979	1980	Total
	(millions of 1973 dollars)							
EPA grant outlays								
Pre-1973 funds[*]	$1,500	$1,600	$ 700	$ 300	$ 200	$ 100	—	$ 4,400
1972 Act funds[†]								
1973/74 allocation	500	1,350	1,650	800	400	200	$ 100	5,000
1975/76 allocation	—	550	2,050	3,300	3,200	2,100	1,100	12,300
Total EPA outlays	$2,000	$3,500	$ 4,400	$ 4,400	$ 3,800	$ 2,400	$ 1,200	$21,700
State and local outlays								
Match for pre-1973 funds[†]	$1,200	$1,100	$ 700	$ 300	$ 200	$ 100	—	$ 3,600
Match for 1972 Act funds[**]	200	600	1,200	1,400	1,200	800	400	5,800
Projects with no EPA funds	500	500	500	500	500	500	500	3,500
Total State and local	$1,900	$2,200	$ 2,400	$ 2,200	$ 1,900	$ 1,400	$ 900	$12,900
Direct capital outlays[††]	$3,600	$5,200	$ 6,800	$ 6,600	$ 5,700	$ 3,800	$ 2,100	$33,800
Cumulative direct outlays	$3,600	$8,800	$15,600	$22 200	$27,900	$31,700	$33,800	—

[*] Including $1,900 million in reimbursables.

[†] Based on the following projection of obligations and upon historical time lags between obligations and outlays (Outlays of $700 million from the 1975/76 allocation will be made after 1980).

Obligations	Allocation		Total
	1973/74	1975/76	
1973 (4th Quarter)	1.6	—	1.6
1974	3.2	1.4	4.6
1975	.2	4.8	5.0
1976	—	5.0	5.0
1977	—	1.8	1.8
	5.0	13.0	18.0

This projection of obligations was made on 11/1/73 and is subject to substantial changes due to such factors as limitations on the total Federal budget, and the rate at which states and localities can produce applications that meet all applicable criteria for grant awards.

[†] Assumes a 1:1 match, but excluding the effect of the approximately $800 million in Federal reimbursables paid in FY 74 but related to construction in place as of 7/1/73.

[**] Assumes a 1:3 match.

[††] Excludes the effect of the approximately $800 million in Federal reimbursables paid in FY 74 but related to construction in place as of 7/1/73.

will be released in the FY 1975 and FY 1976 allocations. The actual rate of allotment will be determined by Federal fiscal policy.

- These allotments will be obligated over the 30-month periods provided for in the 1972 Amendments.
- Federal outlays will continue to lag obligations in the pattern observed in this grant program in the recent past.
- State and local outlays will occur in the same period as related Federal outlays.
- Future Federal outlays from pre-1973 EPA funds will be matched equally by State and local funds.
- Much of the construction begun during the next several years, including all sewerage treatment plants and ancillary facilities (for example, interceptors and pumping stations), will be 75 percent Federally funded.
- Approximately $500 million of sewerage construction, primarily collection sewers, will be built annually without EPA financial assistance.

Although the projection is based in part upon a level of allocations in FY 1975-76 higher than that used when discussing the impact on the construction industry, it provides a reasonable basis for discussing the potential fiscal impact on local government during the next several years.

Local Fiscal Impact. The projection indicates a considerable increase in total capital outlays on public sewerage facilities over outlays made in the recent past (Table VII-2). The 1975 direct outlay of $5.2 billion is almost four times that of 1970. Furthermore, State and local projected outlays on sewerage construction during the next several years will constitute a larger portion (11.6 percent) of their total capital expenditures. Finally, even though EPA grants will make up a much larger portion of total outlays, State

TABLE VII-2

STATE AND LOCAL CAPITAL OUTLAYS, 1961-70

Year	Direct capital outlays[*]			Sewerage outlays only		
	All purposes	Sewerage	% sewerage	EPA grant[†] outlays	State and[‡] local sources	% EPA grant outlays
			(millions of current dollars)			
1961	$ 16,091	$ 747	4.6%	$ 44	$ 703	5.9%
1962	16,791	798	4.8	42	756	5.3
1963	17,638	928	5.3	52	876	5.6
1964	19,087	1,095	5.7	66	1,029	6.0
1965	20,535	1,107	5.4	70	1,037	6.3
1966	22,330	1,202	5.4	81	1,121	6.7
1967	24,233	1,093	4.5	84	1,009	7.7
1968	25,731	1,107	4.3	116	991	10.5
1969	28,240	1,208	4.3	135	1,073	11.2
1970	29,650	1,385	4.7	176	1,209	12.7
Totals	$220,326	$10,670	4.8%	$ 866	$9,804	8.1%
1975 (projected)	$ 43,099[**]	$ 5,200[††]	11.6%	$3,000[††]	$2,200[††]	57.7%

[*] U.S. Bureau of the Census, *Governmental Finances in 1969-70*, Series GF70-No. 5, U.S. Government Printing Office, Washington, D.C. 1971 and preceding issues.

[†] Cash outlays reported to Department of the Treasury.

[‡] Includes funds from Department of Housing and Urban Development, Farmers Home Administration, and the Appalachian Public Work Program.

[**] *The Financial Outlook for States and Local Government to 1980.* Tax Foundation, Inc., New York, 1973.

[††] From Table VII-1.

and local governments will be called upon to contribute approximately $2 billion annually. This is approximately twice what they supplied annually from 1961 through 1970.

Local governments can be expected to finance the non-EPA portion of the projected capital expenditures in a variety of ways. The most common sources of funds are likely to be current general revenues and the issuance of municipal bonds. Several recent studies indicate that State and local governments may run surpluses in their current general accounts over the next several years.[1-3] Hence, most localities may have more flexibility to deal with an increase in sewerage service costs than they have had in the recent past.

A survey conducted in 1969 indicates that localities nationwide had been initiating or boosting "user fees" to finance sewerage services.[4] Of the 1,040 localities that both collect and treat wastewater, 86 percent indicated they levy such a charge. In the aggregate, revenue from user fees exceeded the annual costs for operating and maintaining sewerage facilities, but had to be supplemented by other charges in order to cover debt service payments. The survey indicated a trend for more cities to levy user charges, and for such charges to pay a larger portion of total annual costs. This trend should be reinforced by requirements in the 1972 Amendments that agencies adopt user charges, and, in particular, that such charges be sufficient to ensure that industrial users repay an appropriate portion of the costs of constructing such a facility.

Between 1961 and 1970, approximately 67 percent of funds required by State and local governments for sewerage construction were provided through long term borrowing (Table VII-3). Assuming this percentage continues over the next several years, new issues of sewer bonds would total $5 billion for FY 1974-77 (Table VII-4). A recent study estimated that total municipal bond sales in 1975 would amount to $25.9 billion.[3] The $1.5 billion projected sales of sewer bonds in 1975 would represent 5.8 percent of the total, a percentage only slightly above the 5.2 percent experienced in the recent past.

There are, of course, many factors that will determine the success of localities in the municipal bond market, including:

- *Basic demand for municipal bonds.* The last comprehensive study of the demand for municipal bonds was made in 1966.[5] However, one indicator of a continuing demand is the fact that in the face of generally tight credit markets and record interest rates, interest rates on municipal bonds have fallen from 1970 highs to a current level of approximately 5 percent. In addition, a projection of State and local general finances over the coming decade indicates that debt as a portion of own source revenue will drop from 124 percent in 1970 to 112 percent in 1975.[3] This trend may be generally viewed as a reduction of the risk involved in buying municipal bonds, thereby strengthening demand.
- *Tighter credit market conditions.* Municipal bond sales during the last half of calendar year 1969 were sharply reduced, primarily due to a severe "credit crunch." A Federal Reserve Board study indicated a net short fall of $5.2 billion in long-term State and local borrowing in FY 1970 below a planned level of $18.5 billion.[6] However, in the following year relatively favorable market conditions stimulated a record volume of municipal bonds. The effect on capital spending was apparently minimized by the ability of States and localities to fill the gap with short-term borrowing. A similar response to future credit market conditions of similar severity would be expected.
- *Legal constraints.* State and local governments are generally restricted in the amount of general indebtedness that they

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[1] *Setting National Priorities—The 1974 Budget.* Brookings Institution, Washington, D.C., 1973.

[2] *Public Claims on U.S. Output.* American Enterprise Institute for Public Policy Research, Washington, D.C., 1973.

[3] *The Financial Outlook for State and Local Government to 1980.* Tax Foundation, Washington, D.C., 1973.

[4] *Sewer Services and Charges.* Urban Data Service (International City Managers Association) Washington, D.C., Vol. 2 No. 2. February, 1970.

[5] *State and Local Public Facility Needs and Financing.* U.S. Congress, Joint Economic Committee, 1966.

[6] Peterson, John E. *Response of State and Local Governments to Varying Credit Conditions.* Federal Reserve Bulletin. March 1971.

TABLE VII-3

STATE AND LOCAL SEWER BOND SALES, 1961-70

Year	Construction contracts[*]	EPA grants[*]	State and local funds	Sewer[†] bond sales	% bonds	Total municipal bond sales[‡]	% sewer bonds
			(millions of current dollars)				
1961	$ 763	$ 45	$ 718	$ 624	86.9	$ 99,463	6.6
1962	803	66	737	659	89.4	8,568	7.7
1963	1,004	93	911	607	66.6	9,151	6.6
1964	862	85	777	290	37.3	10,201	2.8
1965	832	84	748	629	84.1	10,471	6.0
1966	919	120	799	591	74.0	11,303	5.2
1967	1,045	134	911	572	62.8	14,643	3.9
1968	1,449	194	1,255	631	50.3	16,489	3.8
1969	1,510	203	1,307	490	37.5	11,838	4.1
1970	1,843	577	1,266	1,180	93.2	18,110	6.5
Totals	$11,030	$1,601	$9,429	$6,273	66.5	$120,237	5.2

[*] EPA files.
[†] Securities Industries Association.
[‡] Federal Reserve Board of Governors.

TABLE VII-4

OBLIGATIONS FOR SEWERAGE FACILITY CONSTRUCTION STATE AND LOCAL FUNDING[*]

Fiscal year	EPA grants[†]	Match for EPA grants[‡]	Other projects	Total	New issues of sewer bonds
			(billions of 1973 dollars)		
1974	$ 4.6	$1.5	$ .5	$2.0	$1.3
1975	5.0	1.7	.5	2.2	1.5
1976	5.0	1.7	.5	2.2	1.5
1977	1.8	.6	.5	1.1	.7
Total	$16.4	$5.5	$2.0	$7.5	$5.0

[*] Assuming that State and local funding is arranged in same period as the related EPA grant.
[†] From Table VII-1, second footnote.
[‡] Assumes 1:3 match.

can issue by State constitutions or statutes. A recent study indicates that debt limits generally inhibit local spending, rather than encourage the use of other sources of funds.[7] A second study, however, asserts that legal debt limitations in general are ineffective in controlling total debt.[8] Debt limits have been avoided through such measures as:

— Issuance of nonguaranteed debt such as revenue bonds.

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[7] Pogue, T. F. *The Effect of Debt Limits: Some New Evidence.* National Tax Journal, 23(1) March 1970, p. 36-44.

[8] Hoggan, D. H. *Can State and Local Governments Assume More of the Costs of Water Development?* Water Resources Bulletin, 8(3) June 1972, p. 626.

- Shifting of financial responsibility to independent authorities, or special districts.

- Use of lease purchase arrangements.

Legal debt limits should continue to be avoidable in most cases.

Most localities will probably not find it difficult to finance their share of the anticipated surge in capital expenditures on sewerage facilities. There will, of course, be individual localities where financing will pose a major problem, perhaps because of unacceptable credit ratings. The source of support in these cases may be the State construction grant programs. In response to earlier Federal legislation, approximately 40 States have established such programs, which can provide up to 25 percent of total construction financing. A second source of financial assistance for these localities will be the Environmental Financing Authority, which was created by the 1972 Amendments "... to assure that inability to borrow necessary funds on reasonable terms does not prevent any State or local public body from carrying out any project for construction of waste treatment works determined eligible for assistance ..." The Authority will begin operation in calendar year 1974. Finally, the Farmers Home Administration is currently making loans for community facilities, including wastewater treatment projects, to communities of under 10,000 population.

Annual Costs. While Federal financial assistance will largely mitigate the fiscal impact on localities of constructing waste treatment facilities during the next several years, localities will largely be on their own when it comes to financing the operation and maintenance of a vastly increased amount of sewerage capital.

The annual expenses of providing sewerage service may be classified as operation costs (plant operation and maintenance, sewer maintenance, and overall administration), and capital costs (interest and depreciation). Both categories of costs may be expressed as a function of the value of sewerage capital in place, which is projected to increase from $35 billion in 1973 to $52 billion in 1977 (Table VII-5). Based upon this estimate, the annual cost of providing sewerage services may increase by 66 percent in the next 4 years (Table VII-6).

In the aggregate, this rapid increase in annual costs should not result in severe pressures on the general revenue of localities because:

- Expenditures on sewerage operations represented just over 1 percent of all current expenditures by local governments in 1970. Even a 66 percent increase would have meant that the cost of sewerage operations was no more than 1.7 percent of all current expenditures in that year.
- As discussed earlier, several recent reports indicate that State and local governments may well run surpluses in their general accounts over the next several years, due in part to the advent of general revenue sharing. Hence, most localities may be better able to absorb an increase in sewerage service costs.

TABLE VII-5

ESTIMATED VALUE OF SEWERAGE CAPITAL IN PLACE

(billions of 1973 dollars)

Value, July 1973*		$35
Net investment—FY 74-77		
Capital Expenditure†	$22	
Less: depreciation‡	5	17
Value, July 1977		$52

*Estimated from net investment in Table III-4.

†From Table VII-1.

‡Based on 4 percent annual depreciation for treatment plant and 2 percent for sewers.

TABLE VII-6

TOTAL ANNUAL COSTS OF SEWERAGE FACILITIES

Category	July 1973 (billions of 1973 dollars)	July 1977
Interest*	$1.7	$2.6
Depreciation †	.9	1.6
Cost capital	$2.6	$4.2
Operations‡	1.2	2.1
Total costs	$3.8	$6.3

*5 percent of estimated value of sewerage capital.

†4 percent for plants, 2 percent for sewers.

‡Based upon an extrapolation of recent trends in the ratio of operating costs to the value of sewerage capital.

- Localities are increasingly utilizing sewerage user fees as a source of income. Hence, although the public will pay increased costs, the impact on local budgets will be further mitigated by a corresponding increase in revenue.

It should be noted, however, that the per capita annual costs of sewerage services can be considerably higher in smaller communities than in larger communities (Table VII-7). These variations, which result primarily from the considerable economies of scale experienced in facility construction, may be even greater for very small communities.

Analysis of Bureau of the Census data yields conflicting indications regarding the ability of the residents in these smaller communities to pay these higher costs (Table VII-8). On the one hand, as per capita income does not vary significantly by community size there would seem to be a real difference in impact on the residents of small communities. On the other hand, as smaller communities generally exert a smaller "own revenue effort" (that is, local governmental income as a percent of personal income), these higher sewerage charges appear to be more than offset by lower burdens from other sources of revenue.

ECONOMIC IMPACTS ON DIRECTLY DISCHARGING INDUSTRIES

The economic impact of the 1977 standards on industrial sectors is highly dependent upon their ability to recover abatement costs through price increases. If they can recover costs, it is anticipated that they will be able to meet the standards. If they cannot recover costs, they will experience declines in profits and in certain instances may have to curtail production or close plants.

TABLE VII-7

PER CAPITA COST OF SEWERAGE FACILITIES, BY SIZE OF COMMUNITY

Community size	Average per capita Costs
25,000	$30.
25-250,000	$19.
250,000	$13.

TABLE VII-8

FISCAL CHARACTERISTICS OF COMMUNITIES, BY SIZE OF COMMUNITY*

Community size	Average per capita income	Average own revenue effort
2,500 to 9,999	$2987	.0209
10,000-25,000	3310	.0238
25,000-50,000	3432	.0267
50,000-100,000	3425	.0296
100,000-200,000	3277	.0326
200,000-300,000	3188	.0377
300,000-500,000	3211	.0405
500,000-1,000,000	3221	.0368
greater than 1,000,000	3730	.0466

*Based on the 1970 Census of Population and the 1967 Census of Governments.

Methodology of Analysis. Recognizing the potential economic problems facing industry in meeting control requirements, EPA contracted for microeconomic studies to be conducted in conjunction with development of effluent standards (VII-9). For each of the 23 industries under consideration an economic impact analysis was performed which focused on the following parameters:[9]

- Price effects—including effects upon an industry's suppliers and consumers.
- Profitability, growth and capital availability.
- Number, size and location of plants that can be expected to close or curtail production.
- Changes in employment.
- Community impacts.
- Balance of payments consequences.

The analysis started with an examination of the costs of pollution abatement in light of existing institutional and market factors.

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[9] The 1972 Amendments require promulgation of effluent guidelines for 27 major industry categories. The effluent guidelines for four major industrial categories have not been completed at the time of publication.

TABLE VII-9

CONTRACTORS FOR MICROECONOMIC STUDIES OF SELECTED INDUSTRIES

Industry	Contractor*
Asbestos	**ADL**
Beet sugar	**DPRA**
Cane sugar	**DPRA**
Cement	**Southern Research Institute**
Dairies	**DPRA**
Electroplating	**ATK**
Feedlots	**DPRA**
Ferroalloy	**ATK**
Fertilizer	**DPRA**
Fiberglass	**No contract**
Fruits and Vegetables	**DPRA**
Flat glass	**ADL**
Grain milling	**DPRA (with feedlots)**
Inorganic chemicals	**ADL**
Leather	**DPRA**
Meat	**DPRA**
Nonferrous	**ADL**
Organic chemicals	**ADL**
Petroleum	**Steve Sobotaka**
Phosphates	**ADL**
Plastics	**ADL**
Paper	**ADL & in-house**
Rubber	**ADL**
Steel	**ATK/Booz-Allen**
Timber	**ADL**

*ADL—Arthur D. Little
DPRA—Development Planning Research Associates
ATK—A. T. Kearney

Primarily this was to determine whether various industry subcategories could meet the necessary capital requirements and recover abatement costs through price increases. Assumptions were made regarding each industrial category's participation in publicly owned treatment works and present levels of abatement. In cases where full recovery of pollution control costs appeared impossible through price increases, some costs were assumed to be absorbed internally, with profits declining accordingly.

Following this step, an attempt was made (using, where feasible, a discounted cash flow analysis) to determine if future cash flows would justify continued operation of various types of plants in light of additional investments required for pollution control. This analysis was done for both the 1977 and 1983 proposed effluent standards.

In performing the analysis, it was necessary to synthesize model plants by size group and to make certain assumptions regarding the relationship between production costs, salvage value, abatement costs, and discount rates. Due to uncertainties inherent in the data (and in some cases, the lack of data), the discounted cash flow analysis was used only as an indicator of the plant or types of plants that could be severely impacted by pollution control requirements and related costs. Final determination of the numbers of plants impacted to the point where closure could be considered a real possibility was made only after consideration of other factors such as geography, land costs, access to municipal waste treatment systems, and other potential alternatives.

Summary Results. The results of the analysis are based primarily on the reports of the contractors and are subject to revision as EPA develops the final versions of effluent guidelines. However, the revisions are not expected to alter the general conclusions of the contractor reports.

An overview of 23 industries discharging directly into the Nation's waters indicates that in most cases they will be able to recover the costs of best practicable wastewater treatment by increases in prices. However, individual plants in certain industries will experience difficulties in meeting the requirements. Generally, the profitability of smaller and/or older plants may be so reduced by pollution control that many of them may decide to close prior to 1977. Secondly, plants located in heavily urbanized areas, especially small older ones, will experience difficulties because they lack the necessary land to use the most cost-effective treatments. This is the case in fruits and vegetables and electroplating where some 546 plants are expected to close. In the absence of adequate municipal treatment facilities the 1977 requirements may force many of these plants to close, relocate elsewhere, or be absorbed by more viable firms.

Not all of the costs will be passed on because of the availability of substitute products and imports. Also, smaller plants in an industry cannot pass on all costs because they may be constrained by larger firms with lower unit costs. Thus some firms will earn lower profits, some will curtail production, and some firms will be forced to shut down.

Prices. Most of the industries studied are expected to raise prices (regardless of potential closures) with the size of the increase varying among segments of an industry (Table VII-10). The industries expected to experience price increases of less than 1.5 percent are *asbestos*, dairies, feedlots, *flat glass*, leather, meatpacking, *nonferrous metals*, softwood plywood, and wood preserving. Price increases of 1.5 to 5 percent are expected to occur in *cement*, *fertilizer*, fiberglass, fruits and vegetables, and hardwood plywood. Price increases higher than 5 percent are expected in electroplating, *hardboard*, *inorganic chemicals*, *organic chemicals*, *paper*, and plastics and *synthetics*. (The industries italicized also face significant air pollution control costs.)

The average price increases do not always reflect the cost of the most difficult waste treatment problems. For example, in both the organic and inorganic chemical industry, the average price increase is no more than 3 or 4 percent. However, in several chemical subcategories, such as titanium dioxide, sodium sulfite, sodium chloride, potassium sulfate, lime, ethylene glycol, and acetic acid, price increases may be 5 percent or greater.

Plant closings. Pollution control costs that cannot be passed on in the form of price increases will result in decreasing profit margins and, in some cases, plant closings. Plant closings are expected in all of the industries with the exception of cement, ferroalloys, flat glass, fiberglass, grain milling, and rubber.

In many of the industries studied, closings will be due primarily to factors unrelated to water pollution control costs, but they will be accelerated by the costs. Feedlots, leather, dairies, and fruits and vegetables are examples. In these industries, many plants are old, family-owned, largely financed with internal capital, and have a low level of long-term debt. Expenditures for new technology have been modest because of difficulty in getting outside capital. Another factor in the closings is that the threatened plants are usually small. Their high vulnerability may be partially explained by a number of factors: lack of access to municipal treatment systems, diseconomies of scale in pollution control facilities, lower efficiencies of operations, and extensive investment required to modernize.

These plant closings may result in a maximum direct unemployment of approximately 50,000 or 1.2 percent of the estimated 3.3 million total employment in the industries studied.

Industry Summaries. The following is a brief discussion of the economic impacts associated with the proposed guidelines for major segments of 23 industries. Although studies have been undertaken of the paper, seafood, steel, and textiles industries, results are not available as the effluent guidelines for these industries have not been completed nor are the relevant economic data available at this time.

Asbestos. Eighty-one firms operating 138 plants are involved in manufacturing asbestos products. Corporations dominate, controlling about 84 percent of the physical facilities and 99.5 percent of the work force. Plants tend to be specialized and are concentrated near metropolitan areas to serve their major markets, the automotive and construction industries. Most larger plants are well over 25 years old.

The economic viability of the asbestos industry will not be seriously affected by the 1977 standards. To meet the goals, the industry will have to invest roughly $3 million, with an annual cost of about $1.4 million. The additional costs, assuming that they are passed on to the consumer, would not exert a significant impact on prices or market competitiveness. Manufacturers will probably absorb the costs because they are negligible and because of competition from substitute products. If costs are absorbed, impact on overall corporate profitability is expected to be minimal since almost all manufacturers are highly diversified.

Most industry plants will be able to comply with the new requirements. No more than four plants, accounting for less than 0.5 percent of total industry capacity, are threatened. The millboard segment of the industry will be most affected, since two of its plants now lack any control facilities and will face high control costs.

Approximately 2 percent of the industry's 13,500 employees work in plants threatened by 1977 standards.

Beet Sugar. Currently, there are 52 plants processing beet sugar in the United States, 38 of them built before 1933. The number has been slowly declining, and in 1971, three plants closed due to higher production costs and relatively low sugar prices. (However, three new plants are due to begin operation in 1974-75.) Most plants are located near supplies in relatively small, rural communities where they constitute a major enterprise. The industry has not been highly profitable, with after-tax return

TABLE VII-10

POTENTIAL IMPACT OF EFFLUENT STANDARDS ON INDUSTRY OPERATIONS[1]

Industry	Price increases to consumer (%)		Plant closings		Unemployment	
	1977	1983	1977	1983	1977	1983
Asbestos	0.1-1.0%	1%	3	1	275	50
Beet sugar	0	[2] n.a.	4-10	n.a.	[3] 2,200-5,500	n.a.
Cane sugar	0	0	3-6	0	300-2,000	0
Cement	1-3	[4] n.s.i.	[5] 0	0	0	0
Dairies	0-.8	0	514-659	0	3,250	0
Electroplating	15	8	517	25	2,397	248
Feedlots[6]	<0.3	n.a.	minor	minor	n.a.	n.a.
Ferroalloys	1.2	n.a.	0	n.a.	0	n.a.
Fertilizer[7]	0-3.5	4-5	23-61	n.a.	590-1,620	n.a.
Fiberglass (wool)	.6-3.8	0	0	0	0	0
Flat glass	0.1-0.3	0-0.4	0	0	0	0
Fruits and vegetables[8]	1-2		29	n.a.	232	n.a.
citrus	1-2	2	n.a.	n.a.	n.a.	n.a.
apple	1-2	2	n.a.	n.a.	n.a.	n.a.
potato	n.a.	n.a.				
Grain milling	0-1.9	n.s.i.	0	0	0	0
Industrial phosphates	.6-1.6	n.a.	0	0	0	0
Inorganic chemicals	[9] 0-2%	0-3	few	n.s.i.	n.a.	n.a.
titanium dioxide	7.7-16.7	[10] 13.4-19.6	n.a.	n.a.	n.a.	n.a.
lime	0-6.4	0-6.4	n.a.	n.a.	n.a.	n.a.
potassium sulfate	6.1	6.1	n.a.	n.a.	n.a.	n.a.
sodium chloride	11.8-19.9	11.8-19.9	n.a.	n.a.	n.a.	n.a.
sodium sulfite	5.9	7.2	n.a.	n.a.	n.a.	n.a.
sodium chromate & bichromate	3.4	4.8	n.a.	n.a.	n.a.	n.a.
Leather	[11] .6-1.3	n.a.	21	[12] n.a.	[13] 950	n.a.
Meatpacking	.1	.3	10	89	400	3,400
Nonferrous (aluminum only)						
primary	minimal	n.s.i.	n.s.i.	n.s.i.	n.s.i.	n.s.i.
secondary	0	n.s.i.	n.s.i.	[14] 6	n.s.i.	160
bauxite refining	0	n.s.i.	2	n.a.	[15] 3,700	n.a.
Organic chemicals	[16] 1.0-4.0	n.a.	[17] some	n.a.	n.a.	n.a.
Petroleum	<1	n.a.	2-11	n.a.	500	n.a.
Plastics and synthetics	0.1-2.4	0.5-6	6-53	1-33	1,100-3,170	0-780
Rubber	0-3.5	0-3.5	0	0	0	0
Timber	1-8	n.a.	75-85	n.a.	1,600	n.a.
softwood plywood	1	n.a.	15-20	n.a.	375-1,000	n.a.
hardwood plywood	2	n.a.	30	n.a.	750	n.a.
hard board	4-8	n.a.	1	n.a.	n.a.	n.a.
wood preserving	1	n.a.	30-35	n.a.	1,050	n.a.

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[1] Potential impact of the 'proposed' effluent limitations on directly discharging industries.

[2] Not available.

[3] Only 200 to 500 are fulltime employees.

[4] No significant impact.

[5] Twenty plants expected to close primarily due to factors unrelated to water standards.

[6] Projected closures are difficult to assess due to importance of many other economic factors and applicability of effluent guidelines. Impact will be heaviest in swine operations.

[7] Industry as a whole is not significantly affected; impacts occur primarily in subcategories where trend is to excess capacity.

[8] Impacts relate only to subcategories of citrus, apple, and potato.

[9] Average price increases for the industry range from 0-3%; however, the six chemicals listed will experience greater price increases.

[10] Figures represent two different processes.

[11] Estimated price increase for large plants is roughly 1.3%; for small plants it ranges up to 20%.

[12] Excludes marginal operations that would have closed without controls. This industry needs additional study.

[13] Plus 5,625 in secondary leather manufacturing.

[14] Wet dross operations.

[15] Potential unemployment estimate for two plants out of nine that have not installed control technology.

[16] Potential price increases may be high as 6 to 12% where waste treatment problems are most difficult, specifically ethylene glycol, ethylene dichloride, caprolactam, ethyl acrylate, acetic acid, para-cresol, and aniline.

[17] Small firms with less than 20 employees will be affected most by the standards.

on sales ranging from −0.2 to 4.0 percent in the past 2 years.

The estimated capital costs for achieving the proposed 1977 level of control range from $4.3 to $7.7 million, with an annual operating cost ranging from $0.4 to 0.8 million. The price increase required to offset the costs ranges between 0.2 and 2.2 percent, depending on the size of the plant, the length of its season, and the current degree of control. Prices are not likely to increase, however, because of Department of Agriculture policies and competition from other sweeteners. Consequently, the profits of some firms may decline.

While most plants in the industry should be able to comply with new standards, some may not be able to absorb the required capital and operating costs and may have to close. Typically, these plants are small, old, and already in jeopardy because of factors such as urban encroachment and declining beet supplies. Even without pollution control requirements, from two to six plants may have to close over the next 10 years. The proposed 1977 standards, which require zero discharge where land is available, threaten an additional four to 10 plants, representing 4 to 13 percent of industry capacity. Assuming each plant has 50 full time and 200 seasonal employees and serves 300 growers, 2,200 to 5,500 people would be affected. Growers might be able to process their beets in nearby plants with excess capacity or in new plants, or they may choose to grow other crops.

Cane Sugar. The cane sugar refining industry will react much as the beet sugar industry. The capital costs associated with meeting the 1977 standards are $5.6 million, with an annual cost of $1.9 million. The price increases required to offset the costs would range between 0 and 2 percent. As in the beet sugar industry, however, prices are not expected to increase. From three to six plants could close, representing 6 to 12 percent of industry capacity. Three of the plants are small rural refineries in Puerto Rico. Since excess capacity exists in the other Puerto Rican facilities, any closings would probably result in a consolidation of the industry, rather than a permanent loss of production. From 300 to 2,000 employees could be affected by the plant closings. Under normal conditions, they should be able to find work in similar occupations.

Cement. There are currently 166 cement plants in operation in the United States; 154 involve nonleaching operations in which water pollution is inherently not a problem. The number of cement plants has been declining in recent years. Plant obsolescence is usually the reason for such closures. Some 10-20 plants could close in the next 4 years, continuing the recent trend. The closing of these plants, generally the older, less efficient ones, may be accelerated if they cannot raise the additional capital necessary to finance water pollution control equipment. The greatest cost pressures have usually stemmed from air pollution.

The total cost of achieving the 1977 standards is $15-17 million for capital investment; total annual costs are estimated at $5.5 million. Impact of the controls might result in a price increase of 1 to 3 percent. Each of the eight leaching plants with the most serious problems may have to invest a half million dollars. The eight are considered to be the most productive and profitable in the industry and so are unlikely to close.

Dairies. Of the 4,870 plants in the dairy processing industry today, as many as a third could close by 1977 through "natural" attrition. An additional 514 to 659 plants representing about 12 percent of industry plants could close as a result of the 1977 water pollution standards. The plants threatened by pollution costs are usually the small, old plants in rural areas. They have less in-plant control, they suffer from diseconomies of scale in control, and they lack access to a municipal treatment system. Furthermore, these operations are already in jeopardy because of other factors such as shrinking milk supplies, difficulties in maintaining sanitary standards, lower efficiencies of operation, and lack of capital to modernize operations. These estimated closings are based on use of activated sludge and sand filtration, now the recommended technology for meeting the standards. The estimates might be slightly lower if less expensive systems such as ridge and furrow or spray irrigation were used. If land were available and climatic problems overcome, these methods might be a viable alternative for the small plants. The estimates are also very sensitive to the percent of plants using municipal systems and the level of control currently in place.

To meet the proposed 1977 standards, the dairy processing industry would have to invest $357 million, or almost 16 percent of the industry's current fixed investment. The required operating costs of $31.7 million, however, would represent only a few percent of sales. The cost of water pollution control would not be passed backwards to the farmer, since most of them are in strong, effective cooperatives and because the Department of Agriculture regulates raw milk prices. Efficient operations would pass the costs—generally no more than 1 percent—on to consumers. The less efficient operations would have to absorb the costs, a significant consideration since their after-tax profits are generally below 1 percent of sales.

The potential closings in 1977 could affect approximately 3,250 plant employees. Milk producers could probably find alternative markets. While the number of employees affected would be relatively low, they would have little opportunity to be reemployed in remaining dairy processing plants. Any new plants that would be built would probably not be located in the same towns where old plants closed. Furthermore, employment in the industry has been dropping because of increased automation.

Electroplating. A wide variety of platings and coatings are used on manufactured items when the base metal does not have the characteristics desired. This study scope was limited to copper, nickel, chromium, and zinc electroplating. The industry consists of approximately 5,600 shops and 78,000 employees.

The industry is characterized by relatively low capital investment in equipment, land, and buildings. Once purchased and installed the market value of equipment decreases rapidly. Annual sales range from $60 thousand to $8 million; however, most of the shops surveyed reported sales of less than $1 million. Total industry sales are approximately $876 million annually.

The total investment required for the electroplating industry to meet the proposed 1977 standards is approximately $481 million, with an annual cost of $35 million.

The proposed requirements by 1977 are not expected to have any significant effect on the production capacity or future growth of the electroplating industry. However, it is likely that significant price increases will result from meeting the proposed standards. These increases are projected to be a maximum of 15 percent for 1977, with additional increases of about 8 percent for 1983. Since these estimates assume that none of the required costs for 1978 have been incurred, the actual increases will be highly dependent on the level of control already attained.

Production effects are expected primarily among low volume independent job shops. Such shops are expected to incur disproportionate cost increases in relation to larger operations. In addition, many of them are expected to have difficulty raising the necessary capital. In the absence of less expensive treatment methods, many of these operations probably would be forced to close. As many as 517 such shops representing approximately 5.4 percent of total job shop capacity and about 2,397 employees might have to close as a result of the proposed 1977 standards.

Ferroalloys. Roughly 85 percent of the ferroalloy industry's output consists of four major alloys (iron-manganese, iron-silicon, iron-chromium, and silicon-manganese) and products from electric furnaces. This study was limited to the nine companies making those products. The firms range in size from annual sales of $20 million to over $3 billion. Some produce only ferroalloys, while ferroalloys represent about half of annual sales of other firms.

The iron and steel industry is the major consumer of ferroalloys. With the high level of steel production, the ferroalloy industry has been operating at full capacity. In 1972, however, its shipments and profitability were severely affected by imports. In addition, air pollution control requirements are becoming a major concern. These two factors are expected to have a greater impact on the industry than the anticipated costs of water pollution control.

Of the 22 plants in the study, 14 (representing over 70 percent of industry capacity) are already using the technology needed to meet the 1977 standards. For the other eight to meet the standards requires an additional investment of $9.5 million. Annual operating costs would increase by $4.0 million. To offset the costs, industry would have to increase prices by 1.2 percent, to maintain its current return on total assets.

Fiberglass (Wool). There are 19 plants producing glass wool in the United States; 15 plants operated by two firms are responsible for about 95 percent of the production. There are no small producers, since the process is basically a high-volume operation. The plants range in size from 5 million to 440 million pounds per year. The majority are multiproduct operations. Plants range in age from 2 to 25 years, with about 30 percent being 10 to 15 years old. Age is not necessarily a good guide to plant efficiency or profitability, however, since most plants have been expanded or modernized over the years.

The primary markets for glass fiber are as building insulation, acoustical ceiling tiles, and insulation for pipes, ducts, process equipment, and appliances.

The industry will have to spend about $10 million to meet the proposed 1977 standards; annual operating costs will be about $3.7 million. Price increases of 0.6 to 4 percent would be necessary to offset the added costs. In the past, however, the industry has been able to offset cost increases by increasing productivity.

No plant closings are forecast from pollution control costs. The industry is operating at full capacity, and demand is expected to increase. One major producer plans to increase capacities in spite of additional pollution control costs.

Flat Glass. The production of sheet, plate, and float glass in the United States is highly concentrated and involves only seven companies. The total capital costs of the 1977 and 1983 standards are less than $1 million, with annual costs below 0.4 percent of the 1972 unit price. The major segments of the industry—sheet glass, plate glass, and float glass—are not impacted by the effluent guideline limitations. Relatively greater problems exist in the industrial segments of automotive glass tempering and lamination. To meet the standards, prices of tempered and laminated glass would have to increase by 0.1 to 0.3 percent. Increases would be passed on by glass fabricators so that the industry's current rates of profitability would not be affected. The capital required should be readily available.

Fruits and Vegetables. There are almost 1,400 plants in the United States that can, freeze, or dehydrate fruits and vegetables. They vary greatly in size, organizational structure, product mix, degree of diversification, and integration. Although about 70 percent process two or more products, plants are specialized in that they are located near concentrations of specific crops and they require specialized equipment. Many of the plants are relatively old, but new equipment has been added so that most are a combination of old and new equipment.

The industry's plants are frequently major employers in their areas. Further, they use a high proportion of unskilled seasonal workers. Curtailed production would therefore have an important impact on lower income levels.

In development of the standards, three segments of the industry were selected for controls: apples, citrus and potatoes.

These three would have to invest $26.1 million to meet 1977 standards; annual costs would be $3.6 million.

Of the 105 plants involved in processing citrus fruit, 41 are strictly citrus processors. The remaining process other fruits or vegetables. About one third of the plants are tied to municipal treatment systems and one third have technology in place that can meet 1977 standards.

Orange juice, which constitutes 90 percent of the industry's business, was used to represent cirtus products in general. Small plants making frozen concentrates would have to increase prices 1.9 to 2.5 percent to recover the costs of pollution control. For plants producing single-strength juice, increases would have to be 4.4 to 5.5 percent. Since the two forms are competitive, the ability to pass costs on may be limited by the fact that two thirds of the plants will not be affected by the standards. Therefore, price increases would most likely be on the order of 1 percent.

Two single-strength plants should have difficulty meeting the standards. They represent 6 percent of single-strength output. If past trends in the canning and freezing industry continue, eight citrus plants would be expected to close by 1977 and 10 more by 1983. However, the standards may hasten the closings so that all 18 would close by 1977. Of the 10,600 employees in the citrus processing industry, only 1.5 percent would lose jobs because of water pollution abatement.

Since over 40 percent of canned orange juice is exported, any major reduction in production could result in losses of exports. Larger plants, however, would probably take up any slack.

Of the 144 plants that process canned or frozen apple products, about 29 pack only apple products. As with citrus processors, two-thirds of apple processors are tied to municipal systems or have technology in place to meet the 1977 standards. The ability to raise prices to recover the 1977 pollution costs may be limited to less than 1 percent. Four plants may have to close, affecting 0.5 percent of the apple processing industry's 14,650 employees. In addition, 12 plants would normally be expected to close by 1977 for other reasons and 13 might have to close early because of the standards.

Prices of potato products may increase by 1.5 to 1.8 percent from the 1977 standards; however, this is only a preliminary estimate since little information is available for analysis.

Grain Milling. Assessment of the grain mill products industry was limited to flour and other grain mill products (including dry corn milling), rice milling, and wet corn milling. These segments account for 20 percent of the industry's establishments and 35 percent of its capacity. The number of plants and companies has been decreasing in all three segments in recent years.

In flour mill products, only corn wet milling will be affected by the 1977 standards. Most of the mills with process wastewaters discharge into municipal systems. For plants that discharge directly to surface waters, the impacts are slight. All rice milling operations discharging wastewaters are tied to municipal systems.

Only in corn wet milling will the cost impact be appreciable. However, no closures or production curtailments are expected. Of 17 plants, five (representing 30 percent of industry capacity) now discharge directly to surface waters; three have some biological treatment facilities, one is constructing a treatment system, and the fifth will soon discharge to a municipal system under construction.

Wet corn milling plants discharging directly to surface waters face the greatest cost burden. To completely cover costs, prices would have to increase 1.2 to 1.9 percent. However, because of the competitiveness of the industry, it is possible that price increases may amount to no more than 1 percent. Thus profitability of some firms would decrease.

The most serious problem may be some mild curtailment of industry growth. Wastewater flows are substantial, and effluent overloads and periodic spills are a recurring problem. Before output can be significantly expanded, improvements must be made in controlling these problems.

Industrial Phosphates. Phosphorus and its nonfertilizer derivatives are the principal products of the industrial phosphates industry. In general, the same companies that make elemental phosphorus also make the derivatives. With two exceptions, the producers are large chemical or petroleum companies for whom phosphorus and derivatives represent only a small percentage of total sales. The companies usually use the products to make other products, creating problems in estimating the profitability of individual products.

Phosphorus is produced by six companies in 28 plants; in addition, TVA is a major producer. Production is concentrated near deposits of phosphate rock in Florida, Tennessee, and the Idaho-Montana area. Because phosphorus plants are generally located near raw materials and because phosphorus is the most economic form in which to transport phosphate values, phosphorus derivatives are usually produced at other locations.

The pollution control costs required for the industry to meet 1977 standards range from $1.40 per ton for food grade dicalcium phosphate to $4.60 per ton for phosphorus. These costs represent an increase of no more than 1.6 percent of current selling prices. A cost increase of this magnitude should have no measurable impact on productive capacity or the economic viability of the industry.

Inorganic Chemicals. The study of a part of the inorganic chemical industry analyzed 23 chemicals: aluminum chloride, aluminum sulfate, chlorine and caustic soda, hydrochloric acid, hydrofluoric acid, hydrogen peroxide, lime, nitric acid, sulfuric acid, calcium carbide, sodium sulfate, titanium dioxide, sodium chromate and bichromate, potassium bichromate, sodium bicarbonate, sodium chloride, sodium silicate, sodium, sodium sulfite, calcium chloride, soda ash, and potassium sulfate.

There is no definite indication that any significant economic impact will result from the 1977 standards. Some small, older plants that are already marginal may be forced to close, but they generally comprise a very minor segment of the industry. With present market conditions, most costs can probably be passed on, at least to the extent that profitability will not decrease markedly. The long-term growth of the industries may be slightly impaired, but these impacts will be far overshadowed by such factors as market trends, technological advances, and productivity.

Price increases ranging from 0 to 20 percent are possible for lime, titanium dioxide, sodium chloride, sodium sulfite, and potassium sulfate.

Sodium chromate and bichromate prices might increase by about 3 percent, but for all the other inorganic chemicals studied, increases will be less than 2 percent, and in some cases, even zero.

Several products appear to be more sensitive to costs because of a wide variability in control costs, low profits, or special market situations. Chlorine-caustic plants using mercury cells will incur greater costs than those using diaphragm cells. For the four or five plants that have not yet invested in controlling mercury, costs may be prohibitive, and one or two of them may close prior to 1977.

In the lime industry, 25 percent of the plants are achieving zero discharge. The remaining plants will try to pass their abatement costs on to the customer. In cases with unique supply-demand situations, the producer may be able to pass on his full cost, but in general a large segment of the lime industry will be at a competitive disadvantage, which may force some small plants to close.

In titanium dioxide production, the major problem arises over the fact that abatement costs are higher for sulfate than for chloride process plants. Current market conditions will probably allow some cost differential to be passed on. Sodium bichromate will probably not be able to pass on abatement costs because of increased competition from imports and substitute products. After-tax profits of bichromate producers could decrease by 30 percent if all costs of 1977 standards had to be absorbed.

Plant closings in the inorganic chemicals industry will depend on both market trends and abatement costs, making it difficult to determine the effects of possible unemployment. The facilities expected to close, however, are generally small and so are a small portion of the industry's labor force.

Since there are now few substitutes for these inorganic chemicals, industry growth would probably not be significantly affected by the standards. To some extent, however, price increases, coupled with minor decreases in profitability and rates of return, might slightly retard the industry's future growth potential.

Leather. The leather tanning and finishing industry consists of a wide diversity of firms, ranging from small family-owned companies and closely held corporations to divisions of large conglomerates. Almost 50 percent of the firms are located in Massachusetts and New York. Over 70 percent of the plants are in buildings 50 years or older, but a substantial number have been rebuilt and modernized. Most plants are highly specialized because tanning equipment and processes are specialized; also, shoe manufacturing has been and continues to be the principal consuming industry, accounting for about three-quarters of all leather used in 1972. It is primarily the 176 wet process tanners that will be affected by the effluent guidelines.

Meeting the 1977 standards would involve capital expenditures of some $37 million, a substantial proportion of the industry's total fixed investment of $130 to $140 million. Raising capital may pose a severe problem.

In this competitive industry only the large firms, which produce at least two-thirds of the total industry volume, can be expected to be able to pass on the entire cost in price increases. Assuming that 60 percent of tanneries are linked to municipal systems, with several large plants incurring only pretreatment costs, actual price increases will probably range from 0.6-1.3%.

The 1977 standards may force closing of about 21 small plants (most of which are not linked to municipal treatment systems). About 2.8 percent of industry capacity and 4 percent of its employees would be affected by the guidelines. An additional 2,850 employees in the leather manufacturing industry might also be affected. An additional 28 plants, affecting about 16 percent of current production, are predicted to close for reasons unrelated to pollution abatement.

Meat Packing. In mid-1973, there were almost 6,000 livestock slaughtering plants in the United States, down from 6,400 in 1971. Many have closed as Federal inspection requirements have been more vigorously enforced. Employment has also dropped as highly automated plants increased the productivity of plant labor.

The industry is characterized by a preponderance of single-plant firms generating a high dollar value of sales. After-tax profits have traditionally been around 1 percent, with smaller local and sectional packers usually doing better than larger regional and national packers. Plants are found in every State, with Iowa, Nebraska, and Texas leading in pounds of liveweight killed. Two factors govern plant location—concentration of fed livestock for slaughter and concentration of demand. The trend in recent years has been to locate plants near livestock.

The study focused on the 1,400 plants that slaughter more than 2 million pounds liveweight annually. If these plants are to meet the 1977 standards, they will have to invest roughly an additional $44 million; operating costs as a percent of sales range from 0.04 to 0.16. The price increase required at the wholesale level to recover all the costs would range from a low of 0.04 percent for large packing houses with baseline controls already in place to a high of 0.5 percent for small slaughter houses with only primary controls currently in place. Because of competition, the actual long-term price increases within the industry should be about 0.1 percent. The increases will be relatively small from the point of view of the consumer but may be very significant to an industry with low profitability.

Potential closings necessitated by the standards are estimated at about 10 plants representing less than 0.2 percent of industry capacity and 400 employees. The small slaughter houses with disproportionate pollution control cost and lower operating efficiencies are most likely to be affected. As many as three-quarters of meat packing houses and slaughter houses are located in communities of less than 10,000 population, so a plant closing could have a noticeable effect on the local economy. Many small communities have only one plant, so that opportunities for reemployment in new or remaining plants in the industry will probably be low.

Nonferrous (Aluminum Only). The proposed standards are expected to have only minimal effects on the secondary aluminum sector and practically no impact on the primary sector. While similar conclusions have been reached concerning the bauxite refining sector, two plants in this industry (representing about 24 percent of total industry supply) are likely to incur very significant cost in meeting the proposed standards. There are good reasons to believe that these plants will remain open, but such decisions ultimately lie with company management.

Within the primary aluminum sector, the current trend toward dry scrubbers to control air pollution should minimize if not eliminate the problems of water pollution control. Accordingly, there should be only minimal cost in meeting the proposed effluent limitations for 1977 and 1983. No price increases, no plant closings, or unemployment are anticipated. Further, there should be no impacts on the balance of trade or industry growth.

Noticeable price increases are not expected within the secondary aluminum industry as a result of the proposed standards. With the exception of the wet dross processing sector, cost increases are expected to be less than 1.1 percent of the sale value of aluminum. Excepting isolated cases of regional monopolies, competition should prevent these costs from being passed on as price increases. Plant closings are expected only in those plants using wet processes for dross and slag milling. In such plants the combined 1977 and 1983 proposed guidelines could lead to cost increases equal to 6 percent or more of the sale value of aluminum. There are six known wet dross operations, representing approximately 160 employees and less than 1 percent of total aluminum production.

The majority of the costs for meeting the proposed guidelines have already been incurred by seven of the nine plants in the bauxite refining sector. Cost increases for these seven plants are expected to range from zero to 2 percent of the sale value of alumina, depending on the levels of control already in place. Cost increases for the remaining two plants may equal as much as 25 percent of the sale value of alumina. Due to the low cost increases for the other seven plants, it is not likely that the cost to these two plants can be recovered through price increases. Their estimated cost for meeting the proposed guidelines are quite high; investment costs are equal to about 18 percent of replacement cost of refining facility, and annual costs are equivalent to 30 percent or more of the total profits normally realized on the manufacture of finished aluminum. In light of some distinct advantages to overseas bauxite refining, these high costs may cause the owners to give serious consideration to closing these plants. Such actions could result in significant short-term disruptions within the aluminum industry. In addition, an estimated 1,2[illegible]0 jobs would be lost, with potential secondary unemployment for an additional 2,500 people.

Organic Chemicals. The organic chemical industry produces 80 to 90 million tons of chemicals each year. Thousands of compounds are made, ranging in production volume from a high of about 10 million tons of ethylene to very small quantities of reagent chemicals. However, 70 chemicals or classes of chemicals account for about three-fourths of the industry's sales.

Nearly 500 companies are engaged in producing organic chemicals; the four largest account for a minimum of 36 percent and the first hundred for more than 92 percent of total shipments. At the other end of the spectrum are 220 plants with less than 10 employees each. The large plants produce a wide variety of different chemicals, and their effluent will generally be treated in a centralized water treatment plant. Many smaller plants dump their effluent into public sewer systems.

The basic organic chemicals are generally produced in large-volume continuous process plants located near their raw material sources—natural gas fields, petroleum refineries, or coke oven operations. Because the basic chemicals are the raw material for upgraded intermediates, these intermediates are frequently made in the same plant to save freight cost, or by purchasers at adjacent plant sites that receive the basic organics by pipeline.

About 35 percent of the industry, based on number of employees, is located in the Northeast. New Jersey accounts for about one-quarter of the industry's total employment. The South is responsible for nearly 45 percent of employment (and much larger percentage of tonnage). The Midwest accounts for less than 20 percent and the West has less than 5 percent of the organic chemical industry's employees. The Gulf Coast, principally Texas and Louisiana, is predominately the source of basic organics, while the Northeast accounts for a major share of the upgraded products such as dyestuffs, flavor and fragrances, and other high-value, low-volume products.

The investment required for the organic chemical industry to meet the 1977 standards is roughly $1.03 billion; annual costs are $210 million. There is no definite indication that any significant economic impact would result from imposition of the standards. Overall, potential price increases range from 1 to 4 percent for the majority of products, but can go as high as 6 to 12 percent for several of the products with the most difficult waste treatment problems (ethylene glycol, ethylene dichloride, caprolactam, ethyl acrylate, acetic acid, para-cresol, and aniline). Since the majority of these products are commodity chemicals with few substitutes, potential price increases will probably be passed on rather than absorbed by the manufacturer.

A seemingly critical area is the small-volume producers of intermediates and end products. Unfortunately, little information is available to facilitate an analysis of their water pollution control costs. For dyes and organic pigments, costs appear to be 2 to 5 percent of selling price but 20 to 50 percent of the selling price of plasticizers. Although many of the producers in this category discharge their wastes into municipal treatment facilities, those plants without access to such a discharge route will probably be forced to close. Firms with less than 20 employees will be most severely affected. Generally, they are located in major urban areas in the Northeast, where the community impacts of any resulting unemployment would be minimal.

Plastics and Synthetics. The plastics and synthetic polymer manufacturing industry covered in the study consists of approximately 280 companies, many of which have multiple plants. Production in 1972 totaled 12,661,000 kkg. The plants are located throughout the United States and its territories, with most major production units located in the Gulf Coast, Midwest, and South.

The plastics and synthetic polymer industry will have to invest $300 million to meet the 1977 standards. Pollution control investment costs are roughly 30 percent of current industry investment based on 1967 figures. For the majority of the industry, price increases of 0.1 to 2.4 percent would be needed to recover the costs. Given the current market, including competition from lower-priced imports, such increases are unlikely. Rather, the near-term result will be a decrease in profitability. In either event, the impact does not appear to be severe, although some already marginal plants may be forced to close from the added burden of pollution costs.

For the plastics industry, the overriding factor is whether increased costs will be able to be passed on to the consumer. In 1971, the industry was overproducing, profits were low, and costs could probably not have been passed on. The reverse was true in 1973, and prices could have risen except for price controls. Based on past history, supply may again exceed demand, making it difficult to pass costs on.

Among the synthetics, there would be no great economic impact on production of viscose rayon. At present, rayon staple producers are optimistic because prices on competitive fibers, cotton and polyester staple are expected to rise. With demand and prices high, producers would switch to staple should demand for textile filament and industrial filament decline. The situation with cellophane producers differs. Markets have been declining and show no signs of a turnaround. Costs are rising, and although they may be offset by increasing costs for competitive materials, this segment does not have the same pricing flexibility as does viscose rayon. The standards are expected to make production of cellophane decline still further. They should have a negligible effect on cellulose acetate and triacetate fibers, however, since producers appear well on their way to compliance.

Petroleum. The costs for the petroleum industry to meet the 1977 standards are approximately $637 million, with an annual cost of $255 million. For the 1983 standards, the total costs are approximately $625 million, with an estimated annual cost of $250 million. In terms of production costs, the annual cost amounts to approximately 5.8 cents per barrel by 1977 and 9.8 cents per barrel by 1983. Although many refineries will be forced to provide additional capital for in-plant alternatives for water conservation (average of 2.3 cents per barrel by 1977), only a small portion of these expenditures would be reflected in price increases, which are estimated to be about 0.1 cents per gallon by 1977 and 0.2 cents per gallon by 1983.

There is tremendous variability in the treatment costs in refineries of less than 25,000 barrels, as compared with the relative stability of costs for larger refineries. Two to 11 small refineries representing at most 0.3 percent of current capacity may incur pollution abatement costs large enough to force their closure. Approximately 100 to 500 out of the 150,000 refinery employees would be the maximum number to face job losses. Since these refineries are located in several geographical areas, the community and regional impacts of even the maximum unemployment do not appear to be substantial.

Although the $1 billion required expenditure for water pollution control appears to be relatively large, it is not expected that this requirement will jeopardize the petroleum industry's capacity for expansion throughout the decade. Estimated capital expenditures for the petroleum industry in 1971 were approximately $7 billion. Furthermore, the industry itself claims to have spent $283 million in 1972 alone on water pollution abatement, while the 1977 guidelines would require annual capital expenditures of only $250 million. With rapidly increasing profitability, the industry should find the needed capital.

Rubber. The U.S. rubber industry consists of two segments. The first is 28 plants producing different types of synthetic rubbers; 18 plants producing a single rubber are part of a diversified plant complex manufacturing other products such as rubber processing chemicals, plastics, and organic chemicals. Most plants are located in heavily industrialized areas, and in the case of synthetic rubber, near sources of raw materials and refineries.

The second segment of the rubber industry consists of 56 plants producing tire and tube products. The plants vary in capacity from 5,000 to 30,000 tires per day. Water pollution problems depend in part on the age and general maintenance of the plant, since most water originates from washdown of facilities and blowdown of cooling water. However, most tire plants have been expanded and modernized since 1967 when belted bias tires were introduced. Older plants located in heavily built-up industrial sections have no land on which to build ponds and lagoons, while the newer ones in less confined areas do.

Most firms in the industry are large with a high level of integration, some of which are owned by the petroleum industry and some of which are not involved in the manufacture of consumer products.

The standards will not seriously affect the economic viability of the rubber industry. The probable price effect on tires and inner tubes is less than 0.8%; and for the synthetic rubbers, the effect is less than 1% except for SBR latex, where the price effect is as high as 3.5 percent. Thus, while price increases of around 1 percent will occur in most segments, not all producers will be able to recover the full cost of pollution by raising prices. The required annual costs for plants in the industry are estimated to range from 0 percent to 3.1 percent of sales.

Timber. The timber industry assessment focused on three segments. Their products are generally noncompetitive; the sectors are in differing states of growth; and, the companies active in one sector are not necessarily active in another.

Hardboard is manufactured primarily from wood cellulose fiber and is used for paneling, siding, furniture, and millwork. The product can be producted by the "dry process," which uses little process water, and by "wet process," which is analogous to the manufacture of pulp and paper and uses substantial process water. The study considered 17 dry process mills and nine wet process mills.

The plywood and veneer sectors was further broken into softwood plywood/veneer and hardwood plywood/veneer. Products within each sector are generally not competitive. Softwood plywood is used for structural applications--for example, exterior sheathing and residential homes; hardwood plywood is used for its decorative qualities--in furniture, for example. Moreover, while both industries have approximately the same number of plants (200), the total output of hardwood plywood and veneer is approximately 12 percent of the softwood sector. The softwood industry is concentrated in the Pacific Northwest and in the Southeast.

The hardwood plywood and veneer sector is characterized by small operations owned and operated by an independent business. The industry is concentrated in the mid-South and Southeast, and also in the North Central and Northeast States.

The third sector of the timber industry is the wood preserving industry. It is composed of more than 400 plants, many of which are small, privately owned companies with long-standing technology and largely depreciated plant and equipment. The top four producers account for about 35 percent of production and are owned by large, public corporations in the chemical and timber products industries.

The 1977 standards will have essentially no major impact on the hardboard and the softwood plywood sectors. The impact is focused more specifically on hardwood plywood and wood preserving, since these industries are more the province of the small, independent business. There will be essentially no overall production in curtailment in any of the four industry sectors. Where plants are forced to close, they will be smaller firms, with relatively little impact on total industry output. In addition, with the exception of the hardboard industry, which is operating at more than 90 percent of capacity, the industry is characterized by flexible capacity. (Certain producers move in and out of production depending on price/profitability levels.) The industries typically operate at 70 to 80 percent of total capacity. Thus, any production deficiency that results from plant closures can be offset by the remaining facilities.

About 75 to 85 plants are predicted to close due to the effluent guidelines. In most cases, these plants are already marginal because of their low profitability over the preceding 5 to 10 years. The added burden of air pollution abatement costs and difficulties in raising capital may result in a shutdown decision.

Price increases will vary by industry segment, but will range from 1 to 8 percent. Unemployment effects will impact most severely on operations in the mid-South and Southeast. The total effect on unemployment will not be great, perhaps 1600 nationwide, but for 30 to 40 individual communities, as much as a quarter of the work force could become unemployed.

CONSTRUCTION INDUSTRY

Recent legislation will make it necessary to increase substantially the rate of construction of new water pollution control facilities and the modification of existing facilities. An increase of the magnitude called for in the 1972 Amendments (from close to $3 billion/year in 1971 to $9 billion/year in 1976) will place additional demands on the capacity of the construction industry to produce these facilities and possibly create an unacceptable increase in the cost of the facilities or in construction costs in general. EPA initiated several studies in order to assess the impact of these expenditures on the construction industry as a whole and the impact on particular sub-sectors of the construction industry.[10]

One type of study estimated the impact of the incremental EPA-stimulated demand on the price and output of the construction industry. Since this type of study assumed that past relationships will hold in the future, unforeseen events such as the energy crisis may lead to basic changes in the system and therefore outcomes may be very different from those predicted. A second type of study examined the possible existence of specific bottlenecks, such as the supply of skilled labor or entrepreneurs, that would limit the construction industry's capacity to meet EPA stimulated demand. The following material describes in some detail one of the macro studies and summarizes the qualitative discussion on specific bottlenecks.

Macro Estimate. Very little analytical work has been performed examining the questions considered in this report. In particular, the study described in this section[11] is only an initial effort to determine the flexibility of construction supply to meet increased demand. As such, the work must be considered preliminary and additional research is necessary to obtain definitive results.

The method of analysis used in this study is an econometric model. The model attempts to reflect the economic behavior of the construction industry through the use of mathematical techniques. A model by its very nature must make certain simplifying assumptions and specify only some of the many relationships which may bear upon the economic behavior of the construction industry. Thus a model represents an aggregation of many relationships. Some models are more complex than others as they attempt to specify the behavior of a particular industry. Accordingly, the results of any model should be viewed with due respect for the balance between detail and aggregation.

Before describing the model in more specific terms it is important to be clear about precisely what questions this analysis addresses. The analysis attempts to estimate the *incremental* impact on the level and price of construction given an *incremental* change in demand due to increased expenditure on water pollution control. The analysis does not examine the determinants of price increases that are unrelated to changes in construction demand. EPA does recognize, however, that the recent devaluation of the dollar has increased the demand for exports (such as a larger European demand for U.S. steel reinforcing rods) and that this change will increase the price of domestic construction and result in some shortages. Similarly, EPA recognizes that uncertainty about future prices and deliveries of inputs into the construction process may result in significant increases in the price of construction.

Description of Models. Model 1, an aggregate model of construction demand and supply, was estimated using annual time-series data for the period 1958-1972.[12] It includes two equations. One represents the demand for construction as a function of the price of construction, the price of other commodities, the level of gross national product (GNP), and the mortgage interest rate. The second equation defines the supply of construction as a function of the price of construction, other prices, and the size of the prime-age male labor force.

Model 2 differs from Model 1 in two principal ways. First, Model 2 includes four equations representing the supply and demand of construction labor measured separately in terms of hours and numbers of workers. The supply of labor is specified as a function of the wage rate in the construction industry, the wage rate in manufacturing industries, and the size of the prime-age male labor force. The demand for construction labor is derived from an analysis of a model of production in the industry. Construction input is assumed to be a function of the levels of capital and labor used as inputs.

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[10] George F. Brown, Jr. and Louis Jacobson, "An Assessment of the Sabotka Study," Order No. P3-01-02905, September 1973.

Bureau of Labor Statistics, Department of Labor, "Manpower Implication of Alternative Levels of Sewer Construction," Agreement No. EPA-IAG-0240 (D), October 1973.

Chase Econometrics Associates, Inc., "The Economic Impact of Pollution Control Expenditures Needed to Meet Waste Water Discharge Standards by 1980 with Particular Emphasis on the Effect on Construction Prices," Contract No. 68-01-1532, April 1973.

Stephen Sabotka and Co. and McKee-Berger-Mansueto, Inc., "The Economic Impact of the Additional Demands Caused by New Environmental Protection Standards," Contract No. 68-01-0554, December 1972.

[11] George F. Brown, Jr. and Louis Jacobson, "An Assessment of the Sabotka Study," Order No. P3-01-02905, September, 1973.

[12] The estimation was carried out using two-stage-least-squares (TSLS) regression procedures.

The second difference in that, rather than examining construction activity in the aggregate, Model 2 identifies five separate sectors and estimates demand and supply equations for each. The five sectors are private residential construction, private non-residential construction, public building construction, public non-building construction excluding sewers, and sewer construction. Over the period of estimation (1969-1972), these five sectors accounted for, roughly 45 percent, 24 percent, 12 percent, 17 percent, and 2 percent of total construction activity. These percentages have shown considerable volatility over time. The public sectors, in particular, can be expected to respond to various legislative programs. Thus, Model 2 consists of 14 equations: four for construction labor and 10 for construction activity.

Results of Models

Demand for Construction. When viewed in the aggregate (Model 1) the demand for total construction appears to be influenced to a far greater degree by overall factors in the economy, (for example, GNP and the interest rate) than by the price of construction. For example, a 1 percent increase in the price of construction is predicted to lead to a decrease of only 0.025 percent in demand. In contrast, a 1 percent increase in GNP would increase construction demand by 0.47 percent, and a 1 percent increase in the interest rate would lead to a 0.22 percent decrease in construction demand. The overall implication is that construction demand is quite price inelastic and is more a function of the overall state of the economy.

This same conclusion applies as well to each of the five separate sectors in Model 2. For each sector, the estimated price elasticity of demand is less than unity. (However, the estimated coefficients are not statistically significant for all sectors other than sewers.) This implies that the percentage change in demand is smaller than the percentage change in price. On a relative basis, public building and public non-building construction respond more to price changes than do either of the private sectors. This may be due in part to the specific policy of using public construction project to even out total demand.

The private sectors, which make almost 80 percent of construction activity, respond more strongly to GNP and the interest rate than to price. Other things being equal a 1 percent increase in GNP would lead to increases of 4.3 percent and 0.93 percent in private residential and private non-residential construction, respectively. A 1 percent increase in the interest rate also has a marked impact on residential construction—Model 2 predicts a decrease of 0.49 percent. This is to be expected. The major 'cost' of purchasing residential construction is the mortgage payment. Changes in the rate of mortgage interest are likely to have greater influence on the total cost of housing than change in construction price. Similarly, the major determinant of business investment in non-residential construction is the expected return from a given expenditure. The return is likely to fluctuate more closely with the general level of economic activity than with the cost of the project.

However, one might expect that the interest elasticity of demand to be greater than the value estimated. A possible reason for the low value is that mortgage money is subject to considerable non-price rationing, particularly at the peak of business activity. Thus the relatively high elasticity of demand with respect to the level of GNP may reflect a high correlation between non-market rationing of mortgage money and GNP. If so, the analysis should have included a measure of the availability of credit (in addition to the rate of interest) in the model. While this variable would modify the importance of the GNP variable, it would not significantly change the estimate of the price elasticity of demand.

The impact of GNP on public construction is also sizeable. A 1 percent increase in GNP leads to increases of 1.2 percent in public building and 0.40 percent in public non-building construction. Increases in the interest rate, while also statistically significant, have a smaller absolute impact on the public sector construction demands. Decreases of 0.2, 0.37, and 0.46 percent in public building, non-building, and sewer construction demand are predicted to result from a 1 percent increase in the interest rate.

In summary, the models suggest that:

- Construction demand is relatively price insensitive, particularly so in the private sector, which makes up the bulk of the industry demand.
- The level of GNP has a much more important impact on construction demand, suggesting that the level of economic activity is a primary determinant.
- The availability of credit may be a more important determinant than indicated by this model. However, it appears that the interest rate would have to undergo quite substantial changes to impact greatly on construction demand.
- The levels of GNP and the interest rate have relatively larger effects on private demand than on public demand.

Supply of Construction. Viewed in the aggregate (Model 1), the supply of construction appears to be quite responsive to both economic factors and the price of construction, which, unlike demand, responds very little to price changes. A 1 percent increase in the price of construction leads to an increase of 6.5 percent in construction volume, while an increase of 1 percent in the prime-age male labor force leads to an increase of 3.9 percent in construction supply. On an aggregate basis, this suggests that construction supply is quite price elastic: Small price changes lead to large changes in the supply of construction.

This same conclusion remains when the five-sector model is considered. The supply of construction appears to respond most to price changes in the private residential and public non-building sectors. The prices of construction inputs have, as predicted, negative impacts upon supply. Of the two variables, construction wage rates appear the more important: in four of the five sectors the wage coefficients exceeds the interest rate coefficient. The impact of construction wages appears particularly large in the public non-building sector: a 1 percent increase in wages is predicted to decrease supply by 1.9 percent. In no other category is the estimated elasticity greater than 1.0.

In summary, the supply of construction appears to have the following characteristics:

- Relatively small price changes elicit sizeable changes in the supply of construction.
- Construction supply increases with the size of the available labor force, but decreases with the price of inputs.
- The largest sector of construction, private residential, is also the sector in which price changes elicit the largest supply response.

Aggregate Impact of the Incremental EPA Stimulated Demand. The aggregate demand and supply curves described in Model 1 and estimated from annual time series data can be combined to assess the impact of additions to demand. An increase in incremental demand over the baseline is estimated to be $4.9 billion for the sewer component of the aggregated construction industry (Table VII-11). It is the component stimulated by EPA. Using the values of the estimated elasticities and parameters for Model 1 to estimate the aggregate impact on 1976 construction, an increase of $4.9 billion results in an increase in total construction of $4.6 billion and an increase in relative prices of 0.6 percent. One effect of higher prices however is to reduce the amount of construction that would take place in other segments of the construction industry. This explains why an increase in $4.9 billion of demand for one part of the construction industry results in a net increase in total construction of $4.6 billion.

This result is shown graphically in Figure VII-1. The impact of an increase in aggregate demand is to shift equilibrium price and quantity from (P1, Q1) to (P2, Q2). The increase in the one component is shown by the differences between Q3 and Q2. The price increase is shown by the difference between P2 and P1. Due to the price increase there is a decrease in demand by other components of the construction industry amounting to the difference between Q3 and Q1. Thus the net increase in total construction demand is shown by the difference between Q2 and Q1.

Construction Labor Market. The supply of construction labor, measured in terms of either hours or employment, appears to respond exactly as theoretically predicted. Wages in both the construction industry and in competing

TABLE VII-11

PROJECTED EPA-STIMULATED AND EPA BASELINE CAPITAL OUTLAYS FOR POLLUTION CONTROL FACILITIES

Facilities	1974	1975	1976	1977
		(billions of dollars)		
Municipal*				
EPA Stimulated (4-4 plan)	0.8	2.1	2.8	1.8
Baseline	2.8	2.9	3.0	3.2
Total	3.6	5.0	5.8	5.0
Nonthermal Industrial Costs†				
EPA Stimulated	1.5	1.5	1.5	0.9
Baseline	1.0	1.0	1.0	1.0
Total	2.5	2.5	2.5	1.9
Thermal Industrial Costs‡				
EPA Stimulated	0.5	0.6	0.6	0.6
Baseline	---	---	---	---
Total	0.5	0.6	0.6	0.6
Total EPA-Stimulated Costs	2.8	4.2	4.9	3.7

*This capital outlay reflects an allotment of $4 billion in FY 1975 and $4 billion in FY 1976.

†This capital outlay is based on the $11.9 billion estimate in Chapter 4 to achieve best practicable treatment. It assumes $2.5 billion capital outlays in years 1973-1976 and a $1.9 billion capital outlay in year 1977.

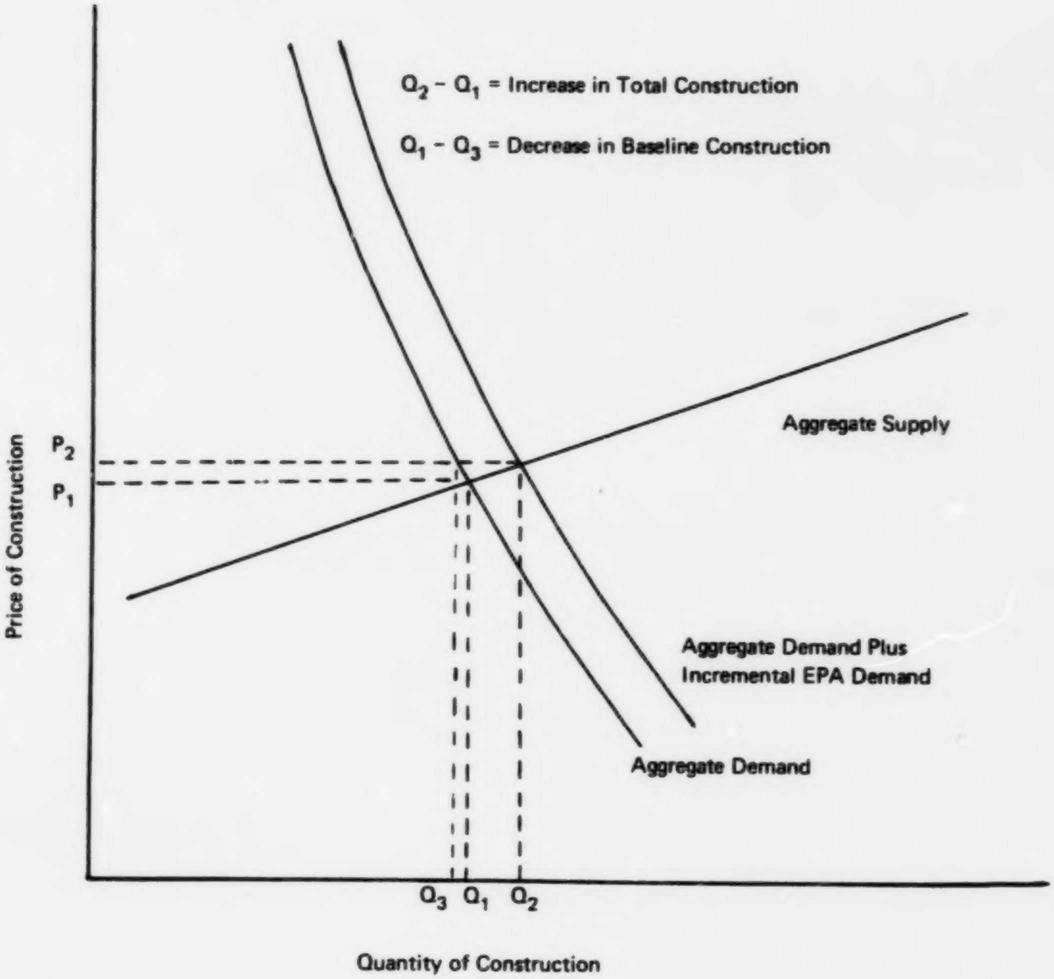
‡This capital outlay is based on the $2.3 billion estimate in Chapter 4 to meet the thermal effluent guidelines given the exceptions provided by Section 316 of the 1972 Amendments. It assumes a $0.5 billion capital outlay in year 1974 and $0.6 billion capital outlays in years 1975-1977.

occupations are important determinants of labor supply. A 1 percent increase in construction wages is predicted to lead to a 2.0 percent increase in construction employment and a 2.2 percent increase in construction hours, while a 1 percent increase in alternative (manufacturing) wages is predicted to lead to a 2.7 percent decrease in employment and a 3.2 percent decrease in hours. The size of the male labor force is similarly an important determinant of supply: A 1 percent increase in the male labor force is predicted to lead to a 1.7 percent increase in employment and a 2.7 percent increase in hours. All of these estimated coefficients are statistically significant.

These results suggest a large and flexible supply of labor to the construction industry. Both the expanding labor force and the rapid supply response to wage changes suggest that the changes in construction activity can be conducted by the existing labor force. (The data did not enable estimates of production functions using disaggregated labor categories. Hence the wage and employment figures represent the current aggregate of skill classes and are not particularly applicable to predicting specific skill shortages that may occur.) Quantitative estimates of these impacts can be deduced from the reduced form employment and hours equations, which result from "solving" the demand and supply equations to give equations relating the endogenous variables to the exogenous variables in the model. From these reduced form equations, the elasticities of construction hours and wages are estimated to be 0.86 and 0.20, respectively. Given the estimates of a $4.6

FIGURE VII-1

SUPPLY-DEMAND RELATIONSHIPS OF THE CONSTRUCTION INDUSTRY



billion in aggregate construction, these elasticities imply an impact of increasing construction hours by 2.8 percent and of increasing construction wages by 0.7 percent.

One additional observation about the construction labor market comes from the estimated labor demand equations. The elasticities of total construction activity on employment and hours are 0.69 and 0.89, respectively. This suggests that the demand reaction may be more heavily concentrated on increased hours per worker than on additions to the construction labor force. Thus, the potential for expansion of hours suggests further capacity for handling short-term fluctuations in construction activity.

Model 2 was augmented to permit estimation of demand and supply for four important skill categories of construction labor—bricklayers, iron workers, plumbers, and electricians. They account for 15 percent of year-long sewage plant construction jobs and 30 percent of the construction trades jobs (Table VII-12).

A 1 percent increase in wages will lead to increases of 3.0 percent in the number of plumbers, 1.8 percent in the number of electricians, 3.3 percent in the number of bricklayers,

TABLE VII-12

ON-SITE YEARLONG JOBS REQUIRED FOR SEWAGE PLANT CONSTRUCTION (1971)*

	Number/billion dollars of sewage construction	Percent of total
Administrative & Supervisory	2,260	9.1
Supervisors & General Foreman	(1,740)	(7.0)
Professional & Technical	(200)	(0.8)
Clerical	(320)	(1.3)
Construction Trades	13,000	52.5
Bricklayers	(450)	(1.8)
Carpenters	(3,200)	(12.9)
Electricians	(870)	(3.5)
Iron Workers	(1,120)	(4.5)
Operating Engineers	(4,565)	(18.4)
Painters	(320)	(1.3)
Plumbers	(1.290)	(5.2)
Cement Finishers	(645)	(2.0)
Other Skilled Trades	(570)	(2.3)
Labor Foremen	570	2.3
Laborers†	7,365	29.7
Other Occupations‡	1,590	6.4
All Occupations	24,800	100.0

*Based on 1,800 man-hours a year per job.

†Includes laborers, helpers, tenders, pipelayers, flagmen, and watchmen.

‡Includes truckdrivers, oilers, and power tool operators.

Source: Bureau of Labor Statistics.

and 1.8 percent in the number of iron workers. These predictions closely correspond to the 2.0 percent increase predicted in aggregate construction labor.

As was the case for aggregate labor, hours respond even more rapidly than employment. A 1 percent increase in wages is predicted to lead to an increase in hours worked of 3.7 percent for plumbers, 2.9 percent for electricians, 4.0 percent for bricklayers, and 2.4 percent for iron workers, versus the overall aggregate estimate of 2.2 percent. This might suggest that barriers to entry, either union-induced or the result of the higher levels of skills required, lead to proportionately larger increases in hours in these four categories than in the other categories. The possibility that these barriers may be somewhat union-induced is further supported by the fact that the estimated elasticities of employment and hours for the size of the male labor force are below those obtained for aggregate labor.

In terms of the impact on wages, a 1 percent increase in total construction activity will lend to increases in the wages of plumbers by 0.06 percent, of electricians by 0.20 percent, of bricklayers by 0.02 percent, and of iron workers by 0.14 percent. These estimates are slightly below those obtained for aggregate labor. Given the $4.6 billion increase in overall construction in the peak year, the model predicts rises of 0.2, 0.7, 0.1, and 0.5 percent in the wages of plumbers, electricians, bricklayers, and iron workers, respectively, from EPA-stimulated demand.

In summary, the labor market flexibility predicted in the aggregate analysis appears to carry over to these four skill categories. An increase in the demand for labor is met to a greater extent by increases in hours and a lesser extent by increases in numbers of workers at least in the short run.

Impact of Capital Markets on Construction. An earlier section of the report concluded that the impact of the EPA-stimulated demand on interest rates would likely be quite small. (For example, peak year incremental funding requirements represent only about 3.0 percent of 1970 gross private domestic investment and 1.0 percent of 1970 mortgage debt.) In addition, the results presented earlier suggest that only very large interest rate changes would substantially impact on construction activity. Even if EPA-stimulated demands cause interest rates to rise as much as 1 percent, overall construction would probably decrease by only 0.22 percent, with a maximum decrease (but of only about 0.49 percent) in the private residential construction category. These liberal estimates of the impact via the capital markets suggest that impacts induced by interest rates will probably be negligible.

Sector Impact. In assessing the impact of the EPA-stimulated demand on the five construction sectors contained in Model 2, it is important to note that the overall impact is predicted to be a decrease of $0.3 billion in the peak year. The private residential and the public non-building sectors are estimated to have the largest relative decrease in construction activity due to their (relatively) high demand elasticities and (relatively) low supply elasticities. Of the predicted decrease in baseline construction, $0.16 billion would be concentrated in the private residential sector and slightly less than $0.15 billion in the public non-building sector. (A conceivable reason for the high demand elasticities for the public sectors is that public works projects are timed somewhat to smooth the overall level of construction activity. Thus these estimates could be somewhat in error if the practice of contracting for public building in periods of slack activity [low prices] is not continued.)

Bottlenecks. To supplement the studies discussed above which examined the flexibility of the construction industry, additional studies were carried out that attempted to examine the possibility of bottlenecks developing that could not be foreseen using the more formal techniques.[13] These studies were based primarily on an examination of the institutional framework of the construction industry. Possible supply bottlenecks examined were manpower, entrepreneurial skills, and construction materials.

Manpower. The ability of the economy to supply sufficient manpower to meet the needs generated by the increased demand for pollution control construction was examined by a special report prepared for EPA by the Bureau of Labor Statistics (BLS). The conclusions of this study can be summarized by the following quotations from the BLS report: "The construction industry in the past had demonstrated a remarkable capability to expand its work force to meet short-term spurts in demand. Shortages in certain construction occupations do occur, however, in some geographical locations during periods of peak demands or as a result of shifts in the composition of construction engineering."[14] These findings are consistent with the results generated by the formal model of labor supply. While there is clearly a potential for a bottleneck to develop, the labor market in the past has been able to adjust adequately. The BLS study did suggest expansion of formal training programs in the certain construction trades to prevent future bottlenecks.

The Sabotka study also examined labor supply conditions and reached similar conclusions with regard to the overall sufficiency of supply. However, the study pointed out that the degree of union power is very large and may lead to significant price increases, particularly if the growth of construction output is sustained at a high rate.

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[13] Bureau of Labor Statistics, Department of Labor, *Manpower Implications of Alternate Levels of Sewer Construction*, Agreement No. EPA-IAC-V0240(D), Oct., 1973.

Stephen Sabotka and Co. and McKee-Berger-Mansueto, Inc., *The Economic Impact of the Additional Demands Caused by New Environmental Protection Standards*, Contract No. 68-01-0554, Dec. 1972.

[14] Bureau of Labor Statistics, Department of Labor, *Manpower Implications of Alternate Levels of Sewer Construction*, Agreement No. EPA-IAC-V0240(D), Oct., 1973, p. 38.

A major problem not specifically addressed in the above studies is the possible impact of Davis-Bacon type legislation. This legislation calls for the payment of the "prevailing" wage on government-supported construction projects. The prevailing wage has come to be defined as the union scale. In many labor markets this represents a significant increase in the construction wage over the actual prevailing level. Frequently this inhibits non-union contractors from bidding on contracts. This institutional arrangement means that even if sufficient capacity exists for an expansion of construction output it will be used only if there is a considerable price increase. In fact, a large increase in Federally-assisted construction, such as called for in the 1972 Amendments, may lead to large increases in construction prices. One study has estimated that a 10 percent increase in the proportion of Federally-financed construction would increase union wages by 6.8 percent relative to wages of production workers in manufacturing.[15]

Entrepreneurial Skill. The large number of contract construction firms, the ease of entry, and the relatively general skills needed to produce water pollution abatement facilities have been pointed out as factors facilitating the expansion of this type of construction. However, there is the possibility that several barriers to expansion exist. The small firm size makes the possibility of business failure very high. This means risk premiums add significantly to the cost of construction. These take the form of performance bonding, which is a type of insurance and high interest rates on bank loans. Also, "tight money" conditions may make an expansion of construction output very difficult.

In addition, the riskiness of construction may cause firms to greatly increase their bids on slightly unfamiliar tasks. The Sabotka Study indicates that while this inhibits expansion it does not inhibit expansion significantly.

Construction Materials. The Sabotka report indicates that the supply of construction materials "could expand to meet any foreseeable demand for the next decade though there might be lags and local shortages." In light of the recent fuel shortages and devaluation of the dollar this optimistic view may need revision. Such commodities, such as steel reinforcing rods, timber products, and even concrete, may greatly increase in price.

EQUIPMENT SUPPLY

Meeting the new effluent standards will have an impact on industries supplying water pollution abatement equipment, especially during the critical period of construction activity extending from 1972 through 1980.[16]

Since industrial activity in the water pollution abatement equipment field cannot be forecast with precision, the demand and impact analyses were performed assuming three alternative futures: (I) a *Baseline* scenario that extrapolates pollution abatement activity from a base year predating major environmental legislation; (II) a *Federal Compliance Schedule* that simulates on-time enforcement of existing standards; and (III) an *Expected Compliance Schedule* that reflects forecasts of what may alternatively occur.

The following analysis was completed in 1972. It was based on statements of equipment suppliers and secondary statistics. Its primary focus was on the productive capacity of the industry rather than the availability of raw material and skilled labor inputs. The latter categories may cause, as recent evidence indicates, some disruptions in short-time supply.

Pollution Abatement Equipment Industry. More than 400 firms participate in the water pollution abatement equipment industry. The four volume leaders hold about 20 percent of the market, which totaled about $475 million in 1971—about $275 million for wastewater treatment and $200 million for water treatment.

The market structure of the industry is complex, frequently involving multiple layers of municipal governments, consulting engineering firms, contractors, local health departments, and federal agencies. One effect of this marketing structure is an extended delay (3 to 5 years) between the decision to buy equipment and its delivery. A second, and maybe more important, effect is the pressure on these parties to protect their respective positions by conservative decision-making. As a result, the municipal water pollution control market is generally slow to respond to federal compliance pressures and to technological change.

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[15] John P. Gould, *Davis Bacon Act: The Economics of Prevailing Wage Laws*, Special Analysis Number 15 (Washington, D.C.: American Enterprise Institute, 1971) p. 38.

[16] Arthur D. Little with U.S. Environmental Protection Agency—December 1972, *Economic Impact Study of the Pollution Abatement Equipment Industry*, Contract No. 68-01-0553.

The industry has enjoyed glamour status, largely due to the great publicity afforded water pollution control problems and programs. Its performance, however, has thus far been a relative disappointment. The pollution abatement equipment business is attractive enough however, to encourage the development of as much long-term supply as may be needed through 1980. There are several reasons that support this conclusion:

- The profit margins enjoyed by pollution control companies on their pollution business have generally exceeded the margins on their other businesses in the same industrial categories.
- Companies in which pollution control is a significant activity (greater than 5 percent of sales) have slightly higher return on assets than companies in which pollution control is a minor activity.
- Comparing the returns on assets, companies "in" the pollution business have out performed those in closely related SIC's.
- Examination of the returns of selected companies in two industries which have indicated strong interests in entering the business—the chemical and aerospace industries—shows that the returns of water pollution control specialty chemical companies were greater than their rates of return.

Demand From Municipal Sector. Aggregate needs for municipal sewage and ancillary facilities were developed from figures in EPA's *Economics of Clean Water* reports. Current market and product mix estimates were based on surveys made by the Department of Commerce. Projections of changes in product mix were developed by the contractor's staff with assistance from persons within the industry. On a constant dollar basis, the recent history of municipal expenditures has been disappointing. The average annual growth since 1965 has only been 0.6 percent per year. This plateau of municipal demand has resulted primarily from the waiting by municipalities for promised Federal assistance—assistance which has not been up to those expectations. The aggregate demand for total municipal sewage system expenditures between 1972 and 1980 is esimated at $27 billion. The mix of expenditures between treatment plants, ancillary facilities, and collection systems were further adjusted to reflect EPA's survey of specific municipal needs. The results of the demand analyses under the three alternative futures are shown in Table VII-13 and Figure VII-2.

Case I—Baseline. The starting line for the baseline projection was 1965, which marked the first promise of significant Federal funds for municipal construction and correspondingly marked the beginning of a plateau in municipal spending that only recently has been exceeded. From the 1965 level of expenditures, the baseline was updated to 1971 by a multiplier (about 1.04) corresponding to the growth in municipal water usage over that period. Similar multipliers were used to grow the baseline over the 1971-80 period. Figure VII-2 shows that the baseline exceeds the level of activity in Cases II and III until 1974, thus emphasizing the impact that the municipal waiting game has had upon not only the progress of the national water pollution control program but upon the operation rates and profits of the water pollution control equipment industry.

Case II—Federal Compliance Schedule. This case reflects at least some flexibility in waiving compliance to contemplated water effluent standards in selected situations, particularly in recognition of the long delay between Federal grants and final equipment delivery in the municipal market. The Federal compliance schedule por[illegible] a fast growing industry that peaks quickly and then falls to a presumed situation of low operating rates and low profits.

Case III—Expected Compliance Schedule. The expected growth of municipal sewage treatment demand encompasses a continuation of lower growth rates in annual investment through 1973, an acceleration of expenditures in 1974-76, and the tapering off to an acceptable growth rate through 1980. Hidden within the curves in Figure VII-2 are the greater growth

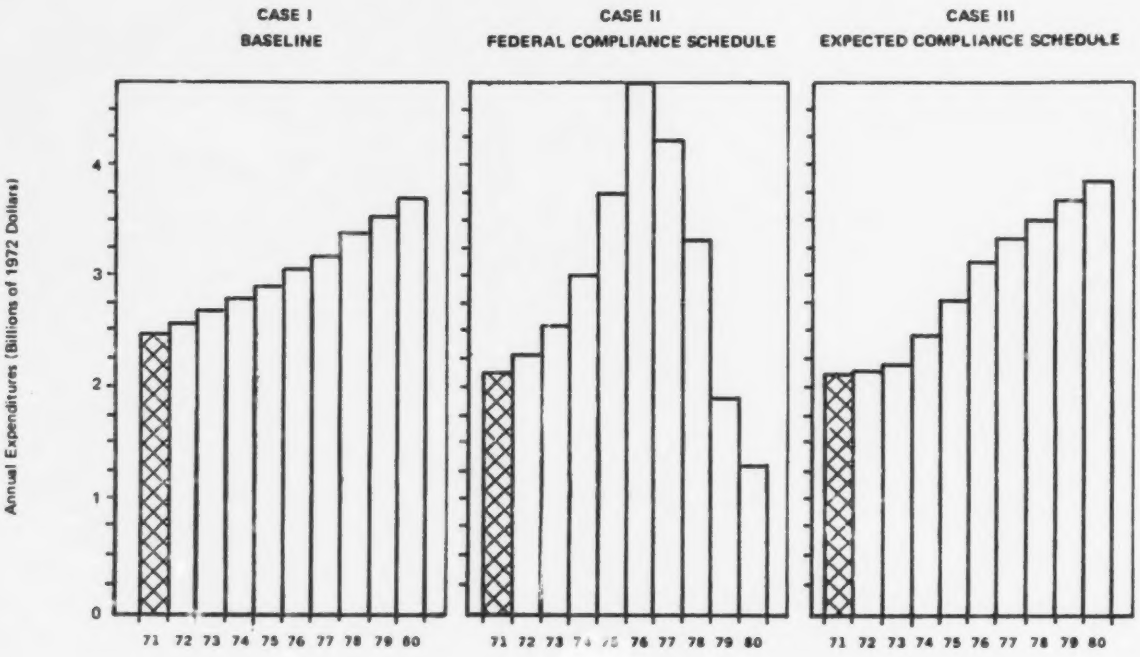
TABLE VII 13

ESTIMATED ANNUAL SHIPMENTS, 1972-80 OF POLLUTION ABATEMENT EQUIPMENT INDUSTRY

	Annual Shipments (Millions of 1972 Dollars)										Growth (%/year)	
	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1971-75	1975-80
MUNICIPAL SEWAGE TREATMENT												
Case I: Baseline												
Specialty equipment	96	100	104	109	114	119	125	132	138	145	4.3	5.0
Instrumentation	11	12	12	13	13	14	15	15	16	17	4.3	5.0
Case II: Federal compliance schedule												
Specialty equipment	110	126	159	221	292	368	300	211	113	73	27.6	-24.4
Instrumentation	17	21	28	39	54	78	65	52	23	15	33.0	-23.0
Case III: Expected compliance schedule												
Specialty equipment	110	114	123	152	186	222	239	255	277	293	14.1	9.5
Instrumentation	17	19	21	26	33	42	48	54	62	69	17.9	15.9
INDUSTRIAL WASTEWATER TREATMENT												
Case I: Baseline												
Specialty equipment	56	59	63	66	69	73	77	81	86	91	5.4	5.4
Instrumentation	13	14	14	15	16	17	18	19	20	21	5.4	5.4
Case II: Federal compliance schedule												
Specialty equipment	172	192	211	228	239	248	151	85	75	63	8.6	-23.4
Instrumentation	26	31	35	38	42	44	28	17	14	13	12.7	-21.0
Case III: Expected compliance schedule												
Specialty equipment	172	184	197	207	213	217	198	124	80	73	5.5	-19.3
Instrumentation	26	30	32	34	36	38	36	23	16	15	8.5	-16.1

FIGURE VII-2

COMPARATIVE EXPENDITURES, 1972-80, FOR MUNICIPAL SEWAGE TREATMENT



rates of specialty equipment indicated in Table VII-13. These higher growth rates for the equipment proportion of the total are due to changes in product mix and the relative proportion of total investment represented by treatment plant expenditures. From the point of view of either specialty equipment or total expenditures, the pattern of growth in Case III presents a more favorable future for the water pollution control equipment industry. However, Case III will also suffer a declining market after 1980, providing new legislative targets are not set by then. The 1972 Amendments affect more the source of monies for municipal sewage treatment than targets of control. Thus, the backlog of needs remain roughly the same, $27 billion.

Demand From Industrial Sector. Reliable information on industrial wastewater treatment expenditures was difficult to obtain. Department of Commerce surveys were used for estimating the level of current equipment shipments and the product mix. From this information, the 1971 market for specialty equipment and instrumentation was estimated at about $192 million (current dollars). Aggregate demand estimates for the 1972-80 period were, with slight modifications, based on *Economics of Clean Water* reports. The aggregate demand for industrial expenditures estimated for the period was estimated to be $9.7 billion. Demand was also forecast for the market for industrial wastewater treatment.

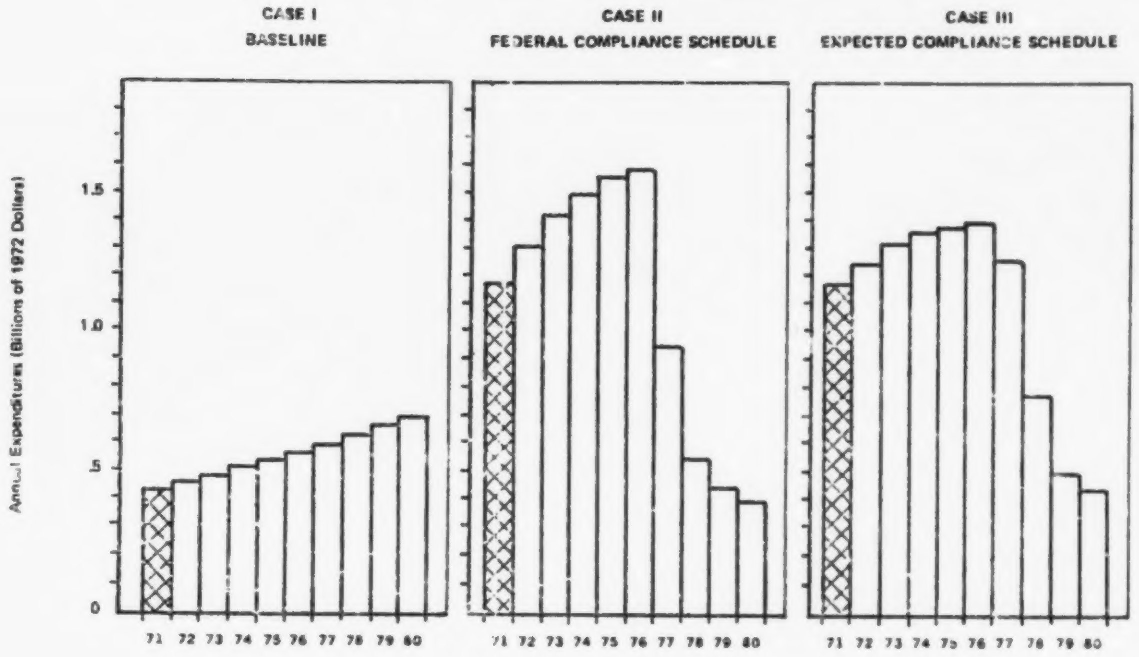
Case I—Baseline. Again, 1965 was selected as the base year. The baseline (Figure VII-3) was constructed using the level of shipments in 1965, a growth index reflecting industrial plant investment (at 5.4 percent per year), and a constant product mix of equipment.

Case II—Federal Compliance Schedule. Since industry responds more quickly to Federal enforcement than municipalities, the majority of industrial wastewater treatment is assumed to be taken care of by 1976. Indeed, the apparent level of expenditures by industry in 1971 is already so high that it took only a small growth rate to achieve the needed expenditures by 1975 (about 7.2 percent).

Case III—Expected Compliance Schedule. Industry will apparently have no great difficulty in accomplishing most of the backlog (as now measured) by 1976. This is partly based on estimates that industrial expenditures are

FIGURE VII-3

INDUSTRIAL WASTEWATER TREATMENT COMPARATIVE EXPENDITURES, 1972-80



already at a level ($1.2 billion) which, with only a modest growth, could reach the estimated target by 1976-77. As a result, in industrial wastewater treatment, the possibilities of a declining market during the 1970's exist in Case III just as they do in Case II. This implies that either industry is close to solving its water pollution problems under present objectives (excluding the implications of the 1972 Amendments) or that the cost of control have been greatly underestimated. Again, specialty equipment expenditures will grow at a faster rate than total expenditures because of the trend toward advanced treatment.

Impacts. The impact analysis focused upon balancing estimates of demand against the supply capabilities of the pollution abatement equipment industry. The analysis was hindered by a serious lack of reliable data on industry supply capacities if capacities are restricted to physical plant and equipment. "Supply" was looked upon in terms of not only physical plant and equipment (the impact of capital) but also in terms of the input of labor and materials.

By combining traditional production theory with basic accounting practice, total revenue was assumed equal to the sum of total payments for labor, capital, and materials. The proportions of these three production factors (as a part of total revenues) were estimated from data on selected SIC industries in the *Census of Manufactures* and from contacts with leading manufacturers. Three to five companies in each of the industry sectors (also employment agencies) were surveyed to determine the supply elasticities of different kinds of labor and materials. This survey was not exhaustive. It was made primarily to assure that the supply elasticities used in this analysis were of the right magnitude. An analysis of the elasticity of interest rates for corporate borrowing over time was made separately to ascertain the effects of increased capital costs upon the final price to customers. These analyses of the capital markets for this industry were confirmed through conversations with leading financial institutions.

The elasticity information from these surveys was then combined into individual supply curves for skilled labor, production labor, materials, and capital. These supply curves were used as annual short-run supply curves, relating increased cost premiums against increases in factory requirements over a given year.

A major simplifying assumption was that the short-run supply curves (actually developed for 1972) would be characteristic of the short-run factor supply markets for the rest of the decade. The second major assumption was that, except for operating effects, the *Census of Manufactures* breakdowns of the factors of production will also remain constant.

The supply curves were generally quite elastic. Supply curves for materials were more elastic than those for production labor, which in turn were more elastic than the skilled labor curves. Supply curves for borrowed capital were actually stepwise curves indicating that above a certain annual increase in capital requirements the interest rate would jump from a lower to a higher level.

The objectives in balancing demand forecasts with empirical supply curves were to indicate what price increases would result if direct cost increases created by supply constraints were passed on to the customers. The demand forecasts were balanced with empirical supply curves. In short, a *cost push* was measured instead of forecasting prices directly. This cost push reflects factor scarcity. The forecast of actual prices would have to include other important considerations besides factor scarcity: the effects of operating rates upon the fixed cost loads, the relative price elasticity to the quality of product and service performed, and the prediction of corporate policies on pricing in times of short- and over-supply.

The economic impact upon the different industry sectors were analyzed in terms of the pollution abatement and closely-related businesses of the leading manufacturers. As the companies involved in water pollution control equipment are equally involved in water treatment markets, forecasts of water treatment equipment demand were included in the calculation of year-to-year growth factors. Similarly, because of a substantial overlap of companies in the air and water instrumentation markets and the probability that the overlap will increase in the future, these two markets were combined.

The comparative inflationary impacts are presented in Table VII-14. The baseline and expected compliance schedules would result in only a 0.3 percent average inflation, whereas the inflation would be 0.8 percent under the Federal compliance schedule.

The results of the analysis, which takes into account supply elasticities and operating rate conditions, are combined in a kind of composite supply curve for each industry component

TABLE VII-14

COMPARATIVE INFLATIONARY IMPACT, 1972-80, FOR WATER POLLUTION CONTROL EQUIPMENT

	Case I	Case II	Case III
	Baseline	Federal compliance schedule	Expected compliance schedule
	Cumulative index	Cumulative index	Cumulative index
1972	1.0007	1.0013	1.0006
1973	1.0013	1.0026	1.0013
1974	1.0020	1.0046	1.0026
1975	1.0026	1.0090	1.0038
1976	1.0033	1.0131	1.0054
1977	1.0039	1.0141	1.0054
1978	1.0046	1.0100	1.0054
1979	1.0053	1.0087	1.0054
1980	1.0060	1.0087	1.0059
Inflated demand 1971-1980 (millions 1972 dollars)	$1,909.4	$3,677.0	$3,640.0
÷ Base Demand 1971-1980 (millions 1972 dollars)	$1,903.0	$3,655.4	$3,636.0
= Average inflation (inflated demand) base demand	0.3%	0.8%	0.3%

(Figure VII-4). These are not true supply curves in the sense of the ones used as inputs to the analysis. They simply summarize a plot of the results of the price impact analysis in the industry. For water pollution control equipment and specialty chemicals, the curve reflects a higher elasticity in the range of anticipated growth rates.

The lack of detailed studies of the manpower requirements in the pollution field for the equipment suppliers, and the smallness of the sample of manufacturers' estimates of the breakdown of the types of manpower they utilize, prevented a detailed statistical analysis of manpower requirements. Based on average sales per employee ratios for leading companies in the business and the demand estimates developed, estimates were prepared of the gross manpower requirements for 1972, 1975, and 1980 (Table VII-15).

In Case III, the total employment is expected to increase from 20,000 in 1972 to 27,000 in 1975 and 30,000 in 1980. Employment in Case II is projected to increase to 35,000 in 1975 (up about 65 percent from 1972) but then decline to 17,000 people (less than current levels) by 1980.

Federal legislation has had a positive employment impact when the estimate of 20,000 people employed in 1972 under expected

FIGURE VII-4

EFFECTIVE "SUPPLY" CURVES
Water Pollution Control

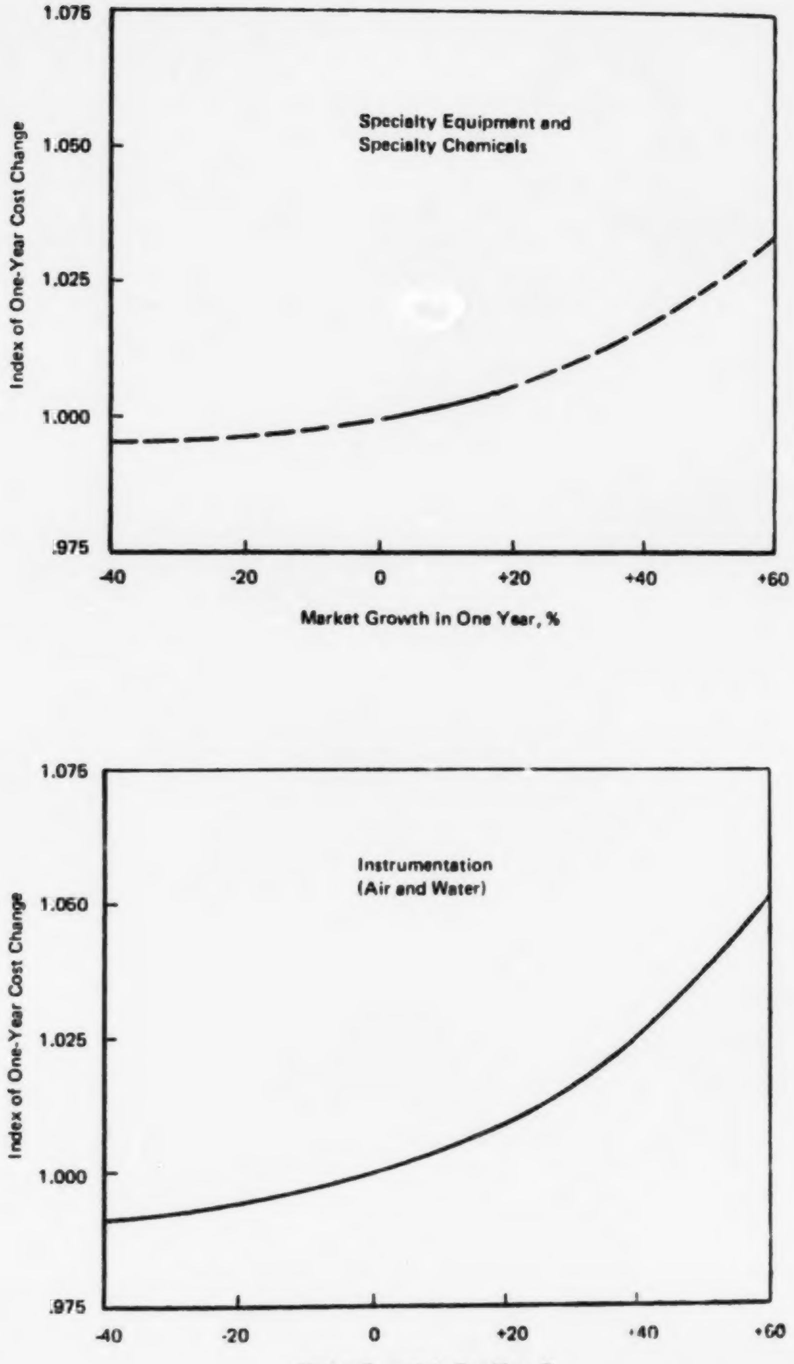


TABLE VII-15

PERSONNEL REQUIREMENTS OF WATER POLLUTION CONTROL EQUIPMENT INDUSTRY, 1972-80

		1972			1975			1980		
	Case	I	II	III	I	II	III	I	II	III
Water pollution control equipment —	Sales (millions)	$ 149	318	298	183	531	399	236	136	366
	Employees	4,890	9,780	9,170	5,630	16,300	12,300	7,260	4,160	11,300
Instrumentation air and water	Sales (millions)	34	80	69	38	198	109	50	45	166
	Employees	1,630	3,830	3,300	1,900	9,470	4,220	2,390	2,150	7,900
Specialty chemicals for water pollution control	Sales (millions)	282	289	289	318	339	336	392	419	418
	Employees	6,880	7,050	7,050	7,760	8,270	8,200	9,560	10,200	10,200
Total Employees		13,875	21,347	20,176	15,829	35,108	26,564	19,888	17,130	30,350

compliance schedules is compared to the estimated 14,000 people under baseline conditions. By 1975, the expected compliance schedule corresponds to an employment almost 170 percent that of baseline conditions. And by 1980 is one and one-half times as great.

A major cause of the present overcapacity in the pollution control industry has been the expectation of promised action. To the degree that standards and deadlines are set realistically and enforced on schedule, future overcapacity should be reduced.

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